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ABSTRACT

Five teams of teacher-researchers, 15 teachers in all, representing three Wyoming school districts and Casper College conducted classroom-based investigations and wrote about their inquiries. These teachers of prekindergarten through college collaborated to examine performance based assessment questions with an overall theme of improving science instruction and assessment. A synopsis of each inquiry report is presented for the following projects: (1) "Collaboration for a Change" (Jayne Hellenberg, Suzanne Morrison, and Diana Wiig); (2) "Who's Supposed To Make the Decisions in the Classroom Anyway?" (Lorrain Rudd); (3) "Phantom of the Rubric or Scary Stories from the Classroom" (Cleta Booth, Barb Deshler, Joan James, and Jane Wade); (4) "Time Is a BIG Thing: A Multi-Age Study of Student Time Schemas" (Anne Marker and Andrea Varcalli); and (5) "A Comparative Analysis of Teacher and Student Perceptions of Learning" (Nancy Brauchie, Colleen Burridge, Elizabeth Horsch, Nancy Leotta, and Julie Horsch). An appendix contains the addresses and telephone numbers of the teacher researchers, and the other presents suggested readings. (SLD)

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COLLABORATION FOR A CHANGE:

Teacher-Directed Inquiry About Performance Assessments

Edited by:
Elizabeth Horsch
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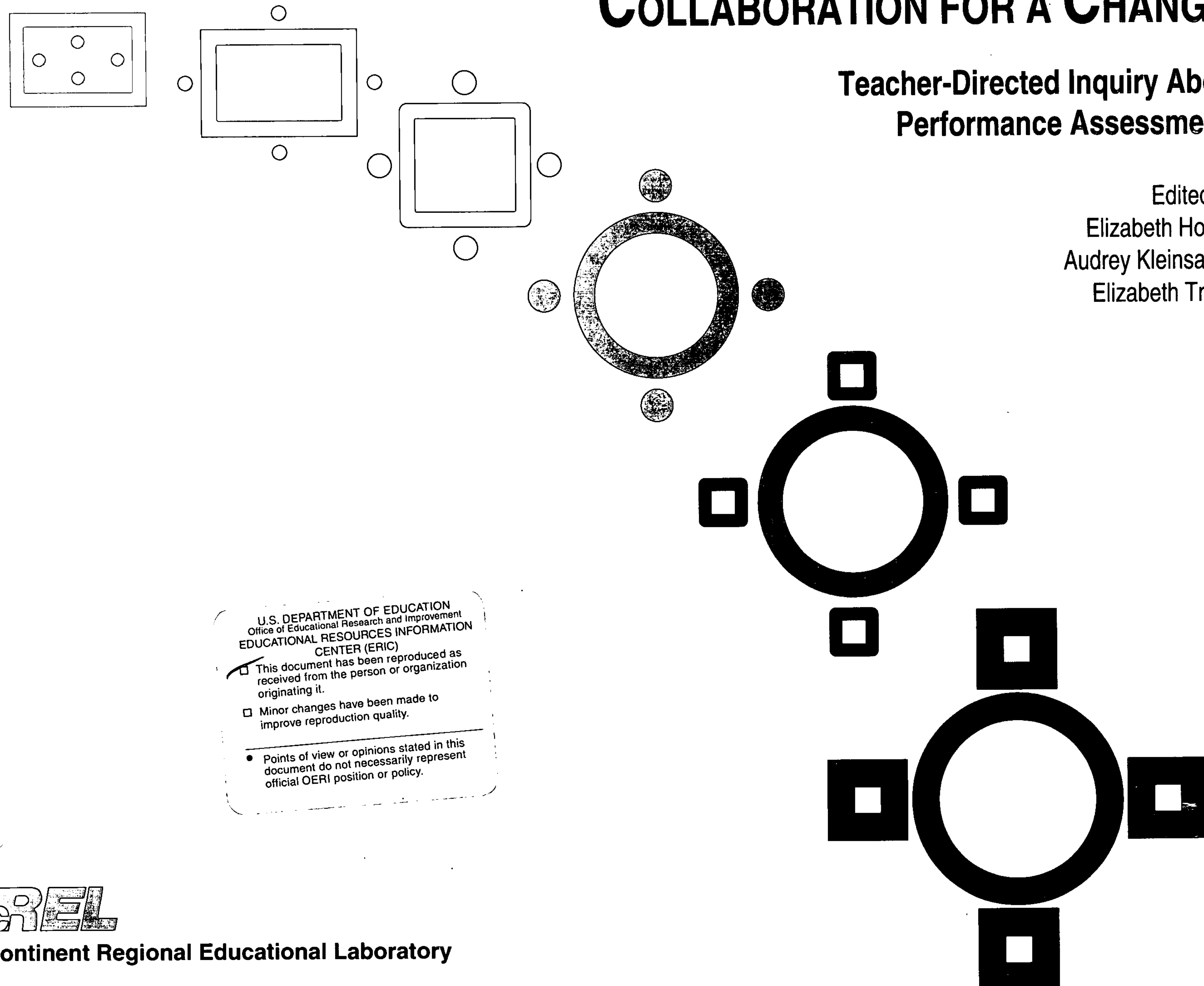

McREL
Mid-continent Regional Educational Laboratory

Collaboration for a Change:

Teacher-Directed Inquiry About Performance Assessments

Reports of Five Teacher-Directed Inquiry Projects

Edited by

Elizabeth A. Horsch, Audrey M. Kleinsasser, and Elizabeth Traver

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FOREWORD

The Eisenhower High Plains Consortium for Mathematics and Science at the Mid-continent Regional Educational Laboratory (HPC at McREL) has been supporting action research projects in the seven state region of Colorado, Kansas, Missouri, Nebraska, North Dakota, South Dakota and Wyoming since 1993. This support has included direct resources, staff assistance, meeting space, materials and publication of the results of the action research projects. We have supported action research because we believe that it is an excellent professional development model that assists classroom teachers in making changes that improve student learning.

The results reported in this publication are very much tied to the classrooms where the research was conducted. This is as it should be. The findings of action research are not intended to generalize to all teachers, classrooms or other educational environments. Nonetheless, readers may recognize in these reports situations or instructional issues similar to their own. Thus, these teachers' results may serve as a springboard for other teachers to look at their own classroom practice.

One's disposition to examine practice or one's position on a continuum of change may influence the way in which these action research reports are viewed. Some may look at the findings and say, "Educational research has already demonstrated that," or, "We already knew that." Others may look at these action research findings and say, "What an insightful observation and interpretation of the classroom environment." While the findings may be known to some at the university level or to some who have been engaged in change efforts, they are seldom widely known at the classroom level. Teachers have little opportunity to familiarize themselves with the findings of educational research, or see very little potential for application of the research in the classroom. After reading the reports, however, they may be inspired to conduct research in their own classroom, gathering data to support or challenge their beliefs and making changes based on what they learn.

We hope that wherever you, the reader, are along the continuum of change, you will keep in mind that the professional educators whose work is presented in this document participated in action research in order to improve their own classroom practice and find ways to help their students be more successful. This publication validates their efforts and serves as a resource for you and for them. It also reminds us that meaningful change often occurs in small increments and in one classroom at a time. When teachers collaborate, however, such change can be accelerated and magnified.

John T. Sutton, Ph.D.
Senior Director
HPC at McREL

INTRODUCTION

By Elizabeth A. Horsch and Audrey M. Kleinsasser

Schools sit squarely in the middle of massive social and technological changes. The student populations they serve are products of these upheavals, and these students are vastly different from the students who attended these same schools just a few years ago (Healy, 1990). Many of the fads and formulas proposed to realign the structure and function of schools and their changing clientele are based on research done with populations of students who bear little resemblance to the students of today. Caught in the confusion of status quo schools, changed students, and misaligned research, thoughtful teachers are beginning to look within their own classrooms for solutions to the mismatch between current educational practices and the students of this time and place.

Nel Noddings (1988, 1989) writes that traditional educational research fails to create a climate of genuine mutuality among colleagues because the research has been directed at the shortcomings and peculiarities of teachers rather than at their needs. She also suggests that the form of inquiry predetermines the type of knowledge it produces. Research conducted in an atmosphere devoid of support and caring is unlikely to generate information which will make classrooms better places for students.

Collaboration for a Change: Teacher-directed Inquiry about Performance Assessments is a collection of five classroom-based investigations. The 15 pre-kindergarten through college teachers collaborated to examine performance assessment questions. Similar to the projects reported in *Innovation in Isolation: Collaborative classroom research focused on mathematics and science performance assessment* (Kleinsasser, Horsch, & Wheeler, 1994), five teams of teacher-researchers representing three Wyoming school districts and Casper College planned, conducted, and wrote about their inquiries.

Both the 1994 and 1996 projects attracted teachers interested in learning more about the way performance assessments really worked in their classrooms. Key to the success of both projects was collaboration at four levels: a) students and teacher; b) teachers within a team; c) teachers across teams; and d) research teams with Audrey and Elizabeth, the project directors.

Teachers inviting students into a conversation about their learning may be the uniquely important, common value in each of the inquiry projects. Student voices provide powerful reminders of who really owns classroom learning and how seldom those faint voices are heard above the noise of educator talk about teaching, learning, and assessment.

Overview of the Project

This teacher inquiry project was co-directed by Audrey, a university-based researcher and Elizabeth, a high school chemistry teacher who was also a member of one of the research teams. Five teams of teacher-researchers from three Wyoming school districts

participated in the project. Six teachers who had participated in a similar teacher-inquiry project (Kleinsasser, Horsch, and Wheeler, 1994) formed the nucleus of three of the teams. Nine new teachers elected to join this second round of the teacher-directed research projects.

The project was supported by a D.D. Eisenhower Mathematics and Science Education Act, Title II of Public Law 100-297 and by tuition. The teachers were enrolled in a two-credit-hour graduate-level course through the University of Wyoming, taught by Audrey. The $15,000 Eisenhower grant supported compressed video costs, the project directors' stipends, face-to-face meeting costs, document preparation costs, and the work of a graduate student assistant.

Two face-to-face meetings were held, one at the beginning and one at the conclusion of the research period. During the course of the project, the teacher research teams communicated with each other and with Audrey through monthly, interactive compressed-video sessions and by conventional mail, telephone, and fax. The teachers' willingness to convene using a distance learning technology illustrated a strong match between an innovative instructional methodology and innovative teachers who felt isolated.

Although each team chose a different topic with a different focus, the Eisenhower project theme was improving science instruction and assessment. For our interactive compressed video sessions, we used and examined three common resources: Herman, Aschbacher, and Winters' (1992) *A practical guide to alternative assessment*, Cochran-Smith and Lyttle's (1993) *Inside/outside: Teacher research and knowledge*, and Kleinsasser, Horsch, and Wheeler's (1994) *Innovation in Isolation: Collaborative classroom research focused on mathematics and science performance assessments.*

A synopsis of each teacher-directed inquiry report follows. The names, school addresses, and telephone numbers of each teacher-researcher are included in Appendix A for the convenience of readers who are interested in finding out more about a particular research project and contacting the teachers directly.

Description of the Research Studies

The research team in Rock Springs, Wyoming included Diane, Suzanne, and Jayne, all elementary school teachers, who wanted to create a professional development experience for teachers that was based on a constructivist view of science teaching. Two questions formed the core of their research: a) What challenges and roadblocks keep teachers from feeling successful while implementing a constructivist approach to teaching science; and b) How can we use the collaborative process to overcome these barriers so that teachers feel more comfortable working together to improve science education? To answer their questions, Suzanne and Jayne agreed to examine their own experiences as they implemented an after-school science and problem-solving program for students grades one through six. Diana would act as a critical friend to observe and document the change process they went through while developing and implementing this program. Although their findings were multifaceted, two interrelated themes were clear. Both teachers and students need time to develop the skills required for this kind of learning, and they also need support in the change process. Even exemplary, experienced teachers are quite fragile. Collaboration with understanding colleagues is a critical element.

Lorrain, a single member team, teaches general and physical science in East Junior High School in Rock Springs. She focused her study on whether poorly motivated students could improve their academic success if they were allowed input into how curriculum objectives were taught and assessed. She conducted her research in her seventh-grade class, using seven students identified as academically at-risk. During the first semester of the school year, Lorrain used a traditional teacher-directed instructional format. At the beginning of the second semester, she explained her research project and invited her students to participate. She included them in classroom decisions on how they might learn the identified

science objectives best, and how they would prefer to have their learning assessed. By the end of the second semester, in the target group of seven, six showed improvement in task completion and three in the quality of the work submitted. When interviewed about the effects of the different approaches to learning, several said that the second semester was more interesting and therefore "easier." Although the seven target students were very enthusiastic about being included in the planning of the learning activities, five of the seven did not receive credit in the class. Interviews with students individually indicated that they did not see the teacher's actions and mode of instruction as central to their success or lack of it. Four of the students responded that they were not "ready to learn." Elaborating on that response, they cited "wanting to do the work," "making school more important than my friends," and "wanting to pass badly enough" as underlying factors for success. Lorrain concluded that interest, relevance, and a feeling of ownership in their education were not enough to guarantee academic success for her seven at-risk students.

Cleta, Barb, Joan, and Jane teach in a laboratory school on the University of Wyoming campus in Laramie. Barb and Joan, experienced teachers but new to the laboratory school, attempted to engage their 50 fourth and fifth graders in a nature study project early in the school year. This experience gave the teachers ample evidence that, although their students were motivated and enthusiastic, they knew little about developing quality projects and oral presentations. Thus, Barb and Joan identified the major questions that would guide their research adventure: a) How do we teach and motivate students to delve deeply into a topic, to plan and work diligently toward the production of a high quality project, and present their knowledge to an audience in an interesting and exciting way; and b) How do we communicate expectations for high quality work to parents? These questions, and a chance meeting with teachers from the 1994 teacher-directed inquiry project, led them to consider forming a research team and ultimately to include Cleta, a pre-kindergarten teacher, and Jane, a middle-school teacher, as a part of the team. The four elected to research the use of rubrics as a possible answer to their concerns about improving the quality of student projects. Their conclusions about rubrics were two-fold: 1) rubrics improved with student involvement in the creation and evaluation of the rubrics; and 2) rubrics, which contain high expectations for achievements and performance, as well as clear standards for process and product, do increase student performance and involvement. The teachers articulated a need to pay attention to what children value as well.

Andi, a science teacher at Dean Morgan Junior High School and Anne, a teacher at Crest Hill Elementary, both Casper schools, along with 44 ninth graders and 25 fifth graders, participated in a study that began as a broad, diffuse look at students' higher order thinking skills and evolved into a focused, integrated, multi-aged project to understand, compare, and broaden students' understanding of time. By engaging these students in collaborative activities which required them to examine their own concept of time in relation to the concepts held by other students, the teachers were able to document that their students at ninth grade and fifth grade were capable of abstract thought. This finding challenged the teachers' belief in a developmental ceiling that determines the cognitive readiness of students to engage in higher order thinking. Their findings led them to consider experience and teacher expectations as significant factors in promoting higher level thinking at an early age.

The Kelly Walsh/Casper College team consisted of five members. Nancy, Sandy, and Elizabeth teach science, and Colleen teaches social science at Kelly Walsh High School. Julie, the fifth member of the team, teaches biology at Casper College. The total number of students included in the study exceeded 280 and ranged in age from 15 to 30. The initial focus of the study was assessment, with the hope of identifying some general indicators of learning. The teachers then attempted to determine if they and the students could agree on whether these indicators demonstrated that learning had occurred. Surveys and interviews with students led the teachers to wonder if they and their students shared a common understanding of what learning is. This questioning gave the research study a

new direction and subsequently a new research question evolved: Do the perceptions of teachers and students differ about what learning is and what is acceptable evidence that it has occurred? Frequent and prolonged conversations with students and survey findings led the research team to conclude that students tend to identify learning primarily as a reflection of what they can do as a result of their educational experience. For students to believe that learning has occurred, they must be able to apply that learning within the context of their real lives. Consequently, it may be extremely difficult, in a traditional classroom setting, to find ways of assessing what students value as real and meaningful learning.

Findings and Reflections

Because the students, the teachers, and the study questions were unique in each classroom setting, the findings were equally as diverse. The powerful impact of giving students a voice in what was taught, and how it was assessed, emerged as a common theme among all the studies, however. As a result of listening to student voices, the researchers in several studies reported that students and teachers seemed to value very different things. At least one study found that parents held yet another view of what was important. This diversity raises perplexing questions about the validity of teacher-designed assessments and what forms of assessment might answer the needs of all three populations.

The difficulty students have with making the transition from a teacher-directed format to student-directed was a less obvious but recurring theme. Several researchers found that students needed a great deal of time to make the transition from a traditional teacher-directed focus to assuming responsibility for their own direction. Rushing the process was counterproductive. One research team observed that teachers also need time and support to make this change. Another researcher cited the difficulty even adult learners faced when they were asked to reflect upon and analyze their own learning.

Finally, collaboration was identified as a critical component of the change process—among students, between teachers and students, and particularly among teachers. The researchers were unanimous in the importance they attached to the support and validation they received from their team members. Teachers were encouraged and supported by their interaction with the larger community of teacher-researchers who shared high professional goals and a common understanding of the problems and complexities inherent in restructuring teaching environments.

Teacher-Directed Inquiry and Consequential Validity

One question which emerged from the 1996 project relates to research and assessment validity. Most research conducted by university- and industry-based researchers adheres to methods which prize traditional positivistic views of reliability and validity. Reliability means dependability of measurement: stability, consistency, predictability, and accuracy. Calculating reliability does not guarantee validity, however. Reliability is only one part of the validity construct. It is significant to note that when educational measurement experts examine validity, they define the construct in question format: Are we measuring what we think we're measuring? That validity is defined by a question rather than a statement forewarns research consumers and producers about the complexity of validating procedures, tests, and programs.

To address the demand for reliability and validity, traditional positivistic educational research has limited itself to a single tool, measurement. When measurement is the only available tool, the results tend to be the same: increasingly sophisticated measurement and statistical techniques used for prediction and generalizability based on large data sets. Such technical sophistication guarantees that discussions about validity will be closed to teachers and learners who take the responsibility for examining the effects of teaching and learning in their own classrooms. While measurement experts talk and write about the statistical properties of assessments, some teachers and learners are validating programs and practices by

trying them out, interpreting results, conversing with parents and local policy makers, and always fine-tuning. It may not be an over-simplification to suggest that measurement experts conceptualize validity one way, and teachers and learners conceptualize it another.

Moss (1992, 1994, 1995) has identified some of the social and ethical consequences of assessment use that go unanswered in traditional assessment inquiry. These consequences include: a) the disenfranchisement of teachers and students from setting their own intellectual problems; b) negative student development; and c) differentiated access to power and authority.

As reflected in evaluation data from the teacher-researchers in this project, one consequence of collaborative, teacher-directed inquiry is positive personal and professional development. As a result of their collaborative projects, the teachers involved in this project think differently about the formerly mute voice of students in the teaching, learning, and assessment conversation. However, by including student voices and, in some instances, negotiating with students about assessment decisions, traditional power and authority are challenged as are traditional validity claims. As illustrated by the reports in this book, troubling contradictions surface about teaching, learning, and assessment.

Mishler, writing in *Harvard Educational Review* (1990), offers an explanation for what happens when teachers and learners enter a conversation about what is valid. He differentiates validity and validation, explaining that a search for validity produces an increasingly static, abstract construct, while a search for validation produces the following:

- a focus on activities rather than static properties of tests, instruments, and scores;
- a focus on functional criteria rather than abstract rules;
- a focus on validation rather than truth finding;
- a reformulation of validation as social discourse between and among teachers, students, and researchers; and
- an articulation of contradictions through social discourse.

Formative and summative evaluation data from this project convince us that teacher-directed inquiry offers the opportunity for positive personal and professional development for teachers. Perhaps a more important consequence is the contribution of teacher-directed inquiry to new ways of thinking about validity by both teachers and learners. It is a consequence warranting further investigation.

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Back in Laramie, we would not have gotten very far without the help of Lorrie Ranck who assisted with the monthly interactive compressed video sessions, numerous mailings and faxes to the teachers, and the final face-to-face weekend meeting. Debbie Martinez, manuscript secretary for the Wyoming Center for Teaching and Learning, took our diskettes and turned drafts from a variety of word processing programs into a unified document. Elizabeth Traver, also of the University of Wyoming, competently edited the work so that the reports were more reader-friendly and enjoyed common formatting. Pauline Magnussen, Wyoming Institute for the Development of Teaching, helped us keep our Eisenhower account in the black and demonstrated endless patience with our accounting queries.

Last, we thank Suzanne and her Rock Springs colleagues for the title of this book which is also the title of their inquiry project. It is fitting that the title comes from the teachers in this project, 15 women whose dedication to understanding learners and learning led them to add classroom-based inquiry to already grueling schedules.

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COLLABORATION FOR A CHANGE

Jayne Hellenberg, Suzanne Morrison, and Diana Wiig

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COLLABORATION FOR A CHANGE

Three teachers representing first through sixth grades collaborated to create a professional development experience for teachers. By reflecting on their own science teaching with a multi-aged group of 60 first- through sixth-grade students in an after school science and problem-solving program, these teachers determined the essential components that lead to effective science and problem-solving instruction using a constructivist philosophy. Knowledge gained through this type of teaching and reflection will be put to use in creating staff-development opportunities for elementary teachers in their school district.

If you are a dreamer, come in,
If you are a dreamer, a wisher, a liar,
A hope-er, a pray-er, a magic bean buyer...
If you're a pretender, come sit by my fire
For we have some flax-golden tales to spin.
Come in!
Come in!
by Shel Silverstein

INTRODUCTION

We began this study with the hope of creating and implementing a district-wide staff-development program for elementary school teachers and with the goal to help them move from a textbook-based curriculum to a more constructivist view of science teaching, a closer alignment with the national Benchmarks for science instruction. (*Benchmarks for Science Literacy*, 1993).

Several years ago, the science committee of Sweetwater School District #1 adopted a constructivist science philosophy. In an effort to implement this philosophy and further help teachers, the committee offered classes in the learning cycle, provided classroom mentors, included administrators in each step of the process, and provided general support wherever needed. The committee felt they had done everything necessary to facilitate the implementation of the constructivist philosophy. The next step was to look at assessing science education in the district. The issue of assessment brought an outcry from teachers because they felt they were not yet comfortable with the constructivist approach to teaching science. Principals throughout the district brought these concerns to the science committee, and the science committee co-chairs were charged with the task of designing a staff-development program. The program had to model appropriate science experiences for students in the classroom, and, ultimately, improve science instruction for the students in the school district.

THE PLAYERS - THREE BLIND MICE

Mouse #3

Jayne Hellenberg has been the coordinator of the elementary gifted and talented program in Rock Springs for the past two years. She provides enrichment activities for 80 academically gifted students, from third through sixth grades, in a one-day-a-week pull-out program. Along with identifying and teaching these 80 students, Jayne also works with classroom teachers, in a staff development mode, to help them provide learning experiences that will enhance the learning of all students.

Mouse #2

Suzanne Morrison teaches a multi-year program at Northpark Elementary School. During her 20 years of teaching, she has worked on developing a science/math based curriculum for children ages nine through fifteen, with a focus on student self-selection. She has an extensive background in science education and has been the co-chair of the district's elementary science committee for the past four years. As a co-chair of this committee, she was put in charge of designing a staff-development model that would facilitate the teaching of "hands-on, minds-on" science in the elementary schools in the district.

Mouse #1 (The Big Cheese)

Diana Wiig was a first-grade teacher at Washington Elementary School during the time this study was conducted. Washington School is based on a team-teaching philosophy, so she, along with her teaching partner, worked daily with 45 first graders. Diana also has an extensive background in science education and, as the other co-chair for the district's elementary science committee, was also charged with designing a staff-development program for elementary science instruction. At the end of the 1994-95 school year, she was selected to fill the new position of science coordinator for the district and would implement the staff-development model for science instruction during the 1995-96 school year.

THE PROBLEM

What challenges and roadblocks keep teachers from feeling successful while implementing a constructivist approach to teaching science? How can we use the collaborative process to overcome these barriers so teachers feel more comfortable working together to improve science education?

THE PROCESS

To help answer these questions, Jayne and Suzanne implemented a constructivist science program with a diverse group of students in an after-school setting. Meanwhile, Diana acted as an observer and documented the successes and struggles.

This report provides the narrative of successes, challenges, and roadblocks Jayne and Suzanne found while implementing their program. By documenting their process, the three teachers hope to better understand and accommodate the change-process/staff-development paradigm in the district. Ultimately, the goal is to use the results of the study to design an effective staff-development program for elementary teachers which will significantly impact the way that science is experienced by and delivered to students.

BACKGROUND INFORMATION

In the summer of 1994, Jayne and Suzanne piloted a week-long summer science program that encouraged students to experiment with science process skills. Students attended classes from 9:00 am - 12:00 noon from Monday through Thursday for a total of 12 hours of instruction. The response from parents and students was very positive and the teachers were encouraged to run the program again, during the 1994-95 school year, as an after-school activity.

Parent Comments about the Summer Program:

- The program was very beneficial to my child. Frequently, it seems real science does not start until fourth or fifth grade. For my second grader, this was a head start.
- My child loved everything about the summer program. He would have liked to have gone for a longer period of time.
- He loved it! Became more enthused each day about activities...and about returning to school. The program encouraged him to think and create more at home.
- I would like to see James continue in this program. I would like to see both an after-school program and summer one.

Student Comments about the Summer Program:

- I liked all the science and experiments we did, they were fun. I also liked how we could do almost everything we wanted to do. It was very fun except for waking up so early in the morning.
- I would do it again because it was fun. I hope that I get signed up again. I guess after a few days I really liked it. I learned that you never, ever sniff things close up, but far away and wave it towards you. I learned about fair tests.
- I wish it was all day so we learned more about science.
- I liked how we did Chemistry, Physical Science, and Centers. In fact, I liked the whole week! I learned that a base and an acid make a chemical reaction. Graphite is better than oil. The more weight your car has, the faster it goes.

For a nominal fee, any elementary student in the first through sixth grades could register for the six-week after-school science and problem-solving course (see Appendix 1A, p. 16). Two sessions, back-to-back, were to be held with 30 students participating in each of the sessions. Students attended classes at Desert View Elementary School (where the gifted and talented program is housed) on Tuesday and Thursday afternoons from 3:45 pm - 5:45 pm for a total of 24 instructional hours. It was hoped that the students would help guide the development of the curriculum for these classes according to their interests, so the two sessions would probably differ significantly. Upon completing the first session, the teachers would discuss the program's successes and struggles and then use the second session to refine and revise their teaching to better meet the needs of the students.

What follows are the goals Jayne and Suzanne hoped to accomplish through the after-school science and problem-solving program:

1. To provide students with the opportunity to explore and investigate their own world.
2. To expand the community of scientifically literate human beings.
3. To teach students that science is more than words in a textbook.
4. To teach students that science does not always produce a "right answer," so one should explore all options.
5. To encourage risk-taking behaviors.
6. To share teaching ideas that bridge grade-level boundaries.
7. To teach students new ways of looking at a problem situation.
8. To provide students with a safe place to explore new ideas.
9. To look at our own teaching and learning in this process, and to be better able to plan an effective staff-development model for teaching science according to a constructivist philosophy.

RESEARCH PROCEDURES - SESSION #1

In Search of Solutions

After much discussion about how to group the students, it was decided to divide the students into primary (first through third grade) and intermediate (fourth through sixth grade) classes with Jayne teaching the primary class and Suzanne taking the intermediate group. Although the students were divided by age level, the intent was to keep the content of the classes similar, making modifications for the developmental needs of the students as well as for their interests.

As with the first day of any new class, we tried to get to know the students by discussing their background knowledge. Both groups of students were asked three questions:

1. What is science?
2. How do you know when you're doing science?
3. What science topics would you like to learn more about?

We received a variety of responses from both groups to all three of the questions. It was interesting to note that while most of the intermediate students looked at science as reading, writing, and taking tests, the primary students seemed to be more free thinking and came up with some other ideas. These students thought science consisted of reading out of textbooks, doing experiments, studying things, making posters and clay models, writing research reports, taking tests and learning about how things work. These children said they knew they were doing science when the teacher told them it was science time, when they got out their science books, when they did experiments, and "I just know what science is!" Several students even mentioned that they didn't think they did science at all in school. As for the science topics they would like to learn more about, the students at all grade levels seemed to draw a blank and didn't really know what they wanted to learn. With this information in hand, Jayne and Suzanne decided to plan a variety of activities for the students to choose from during the six-week session.

During the six weeks, the students experimented with time and movement using pendulums they built; they studied flight and the effects of wind and air pressure on flying objects; they worked with chemical reactions by mixing different substances together; and they talked about designing prototypes for models of cars, boats, gliders, and big wheels. Crystalology, use of microscopes, mapping activities, graphing activities, and math problem solving rounded out the session. On the last day of class, each student evaluated the program. We also sent the students home with a folder of the projects we had completed, a note to parents explaining what we had accomplished, and an evaluation that we asked them to fill out (see Appendix 1a). Several examples of both parent and student comments about the first after-school session follow.

Parent Comments about Session #1:

- Yes, this program was beneficial to my child. It piqued his curiosity. He enjoyed the hands-on experiments because he likes to build things. He always seemed happy after the class. Also, he liked the teacher a lot. However, more emphasis needs to be placed on the outcomes. He seldom could tell me why things happened or didn't happen. This is reflected in the work sheets where he seldom filled in the "what I learned" section.
- The program was very beneficial because the hands-on experience enabled my child to enjoy learning science and math. The program is very successful.
- Yes, the program was beneficial. My child really likes science so all of the projects you did helped him to see them better. I felt the time was just right, but I know my child would like to have continued on.
- The program was very much beneficial to my child, and he would absolutely be willing to participate in this type of activity again. One change I would make is to give the

parents or send home materials with the youth (what you are covering at that time). This would help to answer any questions while at home. I wasn't able to answer questions on some of the subjects. Had I known, I would have had reading or video material available for the extended questions.

- Perhaps the program was beneficial, it's hard to measure now. The child didn't seem to learn concepts (how to graph better), or to assimilate concepts taught. The child complained of disruptive first graders (behaviorally immature, didn't share, ruined, etc.). The sessions were too long. Show them how to graph better.
- After they tried it. Explain concept - discuss and more demonstration by teacher - so something is learned besides just making "gak" or airplanes and leaving. Perhaps it should be a summer program only. We appreciate all your time and effort—just didn't think child benefited.

Student comments about Session #1:

1. What did you like about this class?
   - Well it was fun to me and interesting because of all the fun things we did. I also thought that it was sometimes difficult because of the "tufe projeks [sic]" but I managed.
   - It was cool because we got to do cool stuff.
   - Best—I liked all the messy stuff!
2. What did you learn?
   - Well, I learned lots of things, like making graphs, microscopes, compasses and much much more.
   - I learned what flies good and if you don't have the right amount of ingredients it could still turn out pretty good and if you really try hard you can have fun.
   - Scientists always write and they have to try things again and again.
3. What things do you wish we had done differently?
   - nothing it was fun.
   - no pendulums and more crystals
   - STOP ALL WRIGHTING [sic]. I DON'T THINK SCITISTS WRIGHT THAT MUCH!!! [sic]
4. Would you do this again? Why or why not?
   - Yes, I would definitely do this again.
   - No, because we write a lot.
   - No, because I would already know all the stuff but I would [recommend] it to a friend.

Before beginning the second six-week session, Jayne, Suzanne, and Diana reviewed the parent and student evaluations and discussed their feelings and thoughts about the successes, the roadblocks, and the types of changes that needed to be made for the second six-week session.

DISCUSSION

Jayne and Suzanne's thoughts about Session #1

Starting with the first day of class, we were both a little disappointed that the students didn't have any ideas about science topics they were interested in covering. However, after watching the students' reactions to the exploratory exercise with pendulums, we gained some insight into the students' educational position. Many researchers believe that actually experiencing a situation is what leads to learning. We decided that many of these students didn't have any experience with science exploration, and they were overwhelmed by the choices we offered them. If they were having a hard time exploring the pendulums and coming up with activities

they might like to try with a pendulum, it was clear they weren't ready for the bigger choice of what topic to study.

The first week, students asked us for the right answers. They didn't have any confidence for proceeding in an investigation on their own (without knowing what they were supposed to find out). These students seemed not to know how to play, or maybe they didn't know that it was really okay to play in a school environment. We both felt the fun and joy that should be present in this type of environment was missing because the students were not comfortable with the expectations we had and the learning opportunities we were trying to provide.

After each class session, we had a debriefing period to discuss what happened. During the first week, this discussion centered on our beliefs that the nature of schooling at the present time discourages student interest and initiative in their own learning. Even at their very young ages, these students had learned the game of "tell me what you expect from me, and I will do it."

Our frustrations came to a head during the third class session. We planned a problem-solving activity called Wright Wheels. The students were given a total number of wheels and pedals in a bicycle shop and were asked to use the given information to figure out how many tricycles and bicycles might be in the shop. The activity was a fiasco. The students were allowed to use any manipulatives of their choosing but they appeared to have no idea how to start this problem and were agitated with not being given the correct answer. Most of the students (in all grade levels) gave up on this problem and started goofing around before putting much effort into the problem.

From there, we moved on to an exploration activity with parachutes. The students were given a box full of materials and were asked to create a parachute that would stay in the air for as long as possible. We had asked the students to try at least four different designs, unfortunately, the students were so off-track from the problem-solving activity, the rest of the afternoon continued in a downhill spiral. By the time class ended, we were pulling our hair out.

During the nightly debriefing, we tried to figure out what was going wrong. We weren't having any fun, and we obviously were not engaging the students with these learning activities. The discussion again came back to the disservice schools are providing their clients, and we got a little ugly. Suzanne coined the phrase during this discussion that, "Schools are places of child abuse!" We left school, not knowing where to go, deep in contemplation about why we were doing this to ourselves.

Although you would think that it couldn't get any worse, it did. Suzanne received a phone call from a parent asking about the educational significance of making parachutes. The parent wanted to know where all of this was heading. This conversation was almost the "straw that broke the camel's back." Suzanne decided the way to handle this situation was to let the parent know about the constructivist philosophy and offered to provide copies of research articles on active, constructivist learning. The parent's initial concern was with the value of this "play" activity, but once she understood that the students were learning "by doing" and that we were teaching students science-process skills, the parent was satisfied. It was as if Suzanne had to give the parent permission to allow her children to play and explore during school time.

Without knowing what the other was thinking, we were both ready to call it quits. Had we talked on Wednesday night, we might have reached that conclusion, called the parents, returned the money, and given up. But, as it happened, we both showed up to teach Thursday afternoon, too stubborn to admit defeat. We started the fourth class period by having a discussion about what the students were liking/disliking about the program and what they thought they had learned. To our surprise, most of the students said they were having fun and many of them had worked on the Wright Wheels problem and parachute design at home. Several brought what they had worked on to class and were excited to share what

they had learned. The day was fantastic! The students became truly engaged in the parachute exploration and for the first time, we didn't leave school grumbling. It appeared that things were beginning to turn around. Maybe we needed to quit being so hard on ourselves and give both the students and ourselves time to adjust to this new situation.

During the next four weeks, we continued to monitor the students' feelings about the class and tried to incorporate their ideas into our planning. Students started asking for problem-solving activities to take home or back to their classroom teachers. The learning atmosphere seemed more lively, and we were witness to more risk-taking and student-initiated experimentation. We all survived the last four weeks of class, and, occasionally, found ourselves enjoying it. As the first session ended, we were feeling more positive, but we knew we still had a long way to go in running an effective, constructivist science program. We had given the students many opportunities to explore materials and work on science-process skills; however, Suzanne wondered what the students really learned. Had we taught them anything?

The evaluations we received from both parents and students were generally positive and most of the parents thought their child(ren) had benefited and learned from this experience. Even though we received mostly positive comments and several good ideas for improving the program for the second six weeks, the one not-positive evaluation was the one we spent a great deal of time discussing. We obviously hadn't conveyed to this parent the amount of learning and knowledge construction that was happening while the students were experimenting. The negative evaluation let the wind out of our sails for a while, but, thankfully, Diana brought us back to reality and focused us on both the positive evaluations we had received and the joy in learning we had offered to the students.

Although we grieved for the child with whom we were unsuccessful, we discussed what was successful for other students during the first six weeks. Most importantly, we saw students become more involved with risk-taking behaviors and cooperative ventures during this time period. Also, many of the students began trying experiments on their own at home and reporting the results to us in class. We felt we may have given many of these students the science "bug" and hoped that they would continue science investigations at home after the session ended.

The roadblocks we faced during the first session included several issues. The students were often tired and sometimes cranky after a long school day; they didn't seem to know how to cooperate or ask questions; parents weren't always sure why we were doing science this way; and finally, we weren't sure we were teaching these students anything. Upon discussing these items, we decided to make four major changes during the second six-week session.

1. The students needed some outside time at the beginning of each session. Most of the students came to class directly from school and seemed to need a break before beginning again.
2. We would spend more time with each of the topics we were studying so that students would have more opportunity to work through the exploration, inquiry, and extension processes.
3. We would continue to do problem-solving activities, but decided to focus more on strategy games than computational problems.
4. Finally, we wanted to make sure the students did some writing each day about their experiences. We wanted parents to have a written record of the students' experiments as well as what they thought they were learning from the process.

By the end of the evening, we were eager to implement these changes in our teaching practices and were hopeful that the changes would improve the experience for all concerned. With the continued support of our critical friend, Diana, her feedback, questioning, and rebuilding of our self-esteem, we began to look forward to the next session.

Diana's thoughts about Session #1

As the three of us met, I had the chance to see what many teachers must go through as they try to implement a new philosophy/ strategy in their teaching repertoire. Two very capable, intelligent human beings were tearing their hair out in frustration. Both of these teachers are exemplary when it comes to student choice, student ownership, and student involvement. Why, then, were they ready to quit their after-school program in frustration?

One of my first observations was, "they are being too hard on themselves." One critical comment out of many positive comments was getting way too much attention. When I pointed this out, they agreed, but it was hard to let it go. I thought about myself, and knew I had done the same thing, many times, in the past (and probably will in the future, as well). Being the outsider this time helped my perspective immensely but drove home how truly fragile we are when it comes to our teaching and influencing children. But why are we so prone to self-criticism? Why is there that element of doubt that what we are doing is really the right thing? It comes back to the issue of isolation and innovation. We, as educators, are not encouraged to be different and we do not nurture ourselves when we feel isolated. Planning time is available, but it is not the same as reflective time, and that is the critical component missing from our schedules.

RESEARCH PROCEDURES - SESSION #2

We set a regular meeting time on Monday afternoons before the beginning of the next session and also scheduled a group meeting with Diana every Tuesday evening, determined to be more organized. We came up with five major concepts on which we would focus, unless the students came up with some thoughts of their own: field studies, structures, batteries and bulbs, kitchen chemistry, and strategic problem solving. We had a plan and we were ready to try it again.

Once more, we spent the first day trying to get to know each other. We asked the students basically the same questions we had asked during the first session: 1. What is science? 2. How do you know when you are doing science? 3. If you had the choice to study any topic in science, what would you study? During this session, the students seemed to have more to say, maybe because we had learned from the first experience and were better with probing questions. Once the students got started, the ball seemed to keep rolling. It was, again, interesting to note that the primary students seemed to have a broader perspective about science than the intermediate students.

In response to "What is science?" some of the responses included: building, experiments, mammals, long ago, unknown, uses for things, growth and planting, learning about animals, inventions, getting good at new things, history, part of math, planets, dinosaurs, the earth, reading from a book, writing reports and learning about people. Students claimed they knew they were doing science when you do something that no one else thought of, when you're mixing things, when you try new things, when you are studying things, when you learn about survival, when you do experiments, and one student stated, "Everything you do has something to do with science." Finally, when asked about topics in science they would like to study, many again drew a blank. The answers we did receive were "to blow things up," "to make something," and a whole lot of "I don't know."

From these responses, we felt we had some students who were already on their way to becoming scientifically literate, but the students still didn't seem to know what they wanted to learn about. We decided to go ahead with the topics we had planned and continue to ask the students along the way if they had any special interests we could help them address.

We basically stuck to our initial planning for the second six-week session. During this time we completed the following units:

1. Field studies—at the beginning of each class session, the students would visit a self-selected site in the prairie next to the school. At their field sites the students were encouraged to observe and draw their site from different perspectives, measure and record growth over time of one of the living things in their site, find and classify the types of rocks in their area, make a plot map with directions from the school to their site, find and plant seeds in different types of soil, and conduct other inquires they had about their sites. We also read several Bryd Baylor books as an introduction to some of these activities and to help integrate language arts into our science experiences.
2. Structures—the students spent two weeks exploring the concepts of balance, strength, and stability through building with a variety of materials. After completing a day of free exploration with materials from straws to index cards, wooden blocks to cups, the students spent some time making structures to meet certain constraints of height, strength, stability, and creative design. The final project involved the students in building a three-dimensional structure with newspaper in which all of their group could fit.
3. Batteries and bulbs—the students explored the concept of a circuit by finding the many ways to light a bulb with one battery, one bulb and one piece of copper wire. After this initial investigation, the students were offered opportunities to work with parallel and series circuits, electromagnets, and other experiments of the students' choice.
4. Kitchen chemistry—the students explored simple chemical reactions and discussed the difference between a physical change and a chemical change. We explored the reaction of vinegar and baking soda and learned to measure the amount of carbon dioxide produced. Students were able to explore changing variables to produce a silly-putty like substance and observe the reaction that takes place when mixing acetone and packing peanuts. Finally, the students were invited to perform experiments involving emulsions and non-Newtonian fluids.
5. The students also worked weekly on graphing activities and problem-solving activities that encouarged them to think strategically. As the school year drew to a close, both we and the students were tired and didn't want to work too hard. We made it through the six weeks, but there were things we wished we had done differently.

To see if students and parents also had suggestions for changes, we once again asked students to complete an evaluation of the six-week period. A note about the program, along with a parent evaluation form, was sent home in the students' journals (see Appendix 1a). Some of responses from parents and students follow.

Parent Comments about Session #2:

- Yes, this program was beneficial. It gave her a chance to work with science and math in a more relaxed environment than the traditional classroom. She had a chance to interact with children of similar interests. Joanie is a kinesthetic learner—so this was ideal. It helped build her confidence and show her how to relate knowledge to daily life.
- Yes, this program was beneficial. Katie not only learned so much—about science, habitat, computers, but she made new friends. I feel that is very important. I also appreciated the dedication of both Quest teachers. I truly commend you!
- This program was very beneficial to Jonny because he enjoys learning in a hands-on environment. Jonny was excited and full of information to share with us after every class. Jonny is more excited than ever to increase his knowledge in math and science as he understands more fully how it helps in real life situations.

- No, this program was not beneficial. Unfortunately, our child, who was so eager and enthusiastic to be in this program (our child persuaded us to be part of this program) lost interest during or shortly after the 3rd or 4th day. We both have backgrounds in science and our children, including this child, have always been exposed and interested in exploring science - at their level - as well as the world around them. Our child came home with complaints that there was too much repetition and that it was boring. "All we do is the same thing."

Student Comments about Session #2

- It had neat experiments and it was educational. I would take the class in the summer because it has fun and educational experiments.
- I like after school Quest because I always glue myself to the TV when I get home from school and now I have somewhere to go. I also like it because you can learn new things about science. Yes, I would take it again in the summer because it is fun and you never get bored, but no, because in the summer I like to play with my friends.
- I learned a lot about doing things and different ways to do things. I didn't like the electricity part. I thought that was boring!
- I didn't like field sites and charting everything there. I would not take this class in the summer because it's boring!
- I liked doing batteries and bulbs. And how we lighted the bulbs with the batteries. I didn't like having it after school and I wish we got to learn about robots. I would not take it this summer because I don't get to play with my friends.

We were all drained by the end of the second session, so we decided to go back to our own classrooms and finish out the year before we spent any more time trying to figure out what all this stuff means. After a good long break, the three of us got together during the summer to discuss the program and where we would head from here.

DISCUSSION

Jayne and Suzanne's thoughts about Session #2

After the first day of class, we discussed why the students might have had more ideas about what science was. Of course, it was a new group of students and every group is different, but we also thought that the way we asked the questions and probed the students for answers had some effect. We again noticed that the primary students ideas about science were much broader than the intermediate students. We decided that this does say a lot about the types of science learning activities the intermediate students are getting in our schools. We also thought it would have been interesting to keep all of the students together for this activity to see if the younger students could spark some ideas for the older students. If we try this program again in the future, we'll be sure to test out this theory.

The unit on field studies started out fairly well. The students enjoyed being outside and did some good initial drawings. They were fascinated by using thermometers to take the temperatures at different levels of their sites and using magnifying glasses to get a closer look at nature. However, by the third week, what we thought were wonderful lessons, some students were finding boring. We added variety while allowing students to make observations about their environment and to conduct outside research. We even tried to get the students to tell us some activities or experiments they would like to perform in their sites, but they didn't have any ideas. At the end of the six weeks, the reaction to the field site studies stretched across the whole gamut from loving this time to hating it. We had to wonder if the students who found the field studies boring ever spent time outside exploring the world on their own.

The unit on structures was probably one of the most successful topics we studied. The first day we did free exploration, and the students loved it. There were no guidelines on what or how to build. The students had no trouble digging into this activity, and the afternoon flew by. At the end of the class period, each group shared one or more of the structures they built and talked about the trials they had gone through to improve upon their initial design. We felt there was some real "science talk" going on, and the free exploration time was a great ice-breaker for students to get to know one another and work cooperatively in a non-competitive way. We had tried to use this same idea with the pendulum activity during the first session, but we concluded that their lack of knowledge about pendulums inhibited their explorations. Building things, on the other hand, is something that students spend a lot of time exploring on their own, so it was a perfect activity to get this session rolling. During all of the class sessions on structures, the excitement stayed high, and the students were able to communicate both verbally and in writing what they were learning about strength, stability, and balance. The final activity, involving building a three-dimensional structure, proved extremely difficult for most of the groups. The experience gave us the opportunity to point out that science isn't always easy, and sometimes it takes years for scientists to conduct their experiments. Overall, this unit seemed to start the second session off on the right foot, but next time we'll include more time and planning so students will be more successful and less frustrated.

The graphing and problem-solving activities also went well. The students were allowed to work with partners of their choosing for most of the activities, and they enjoyed the game aspect of the problem-solving activities. After only six weeks, we were able to see some growth in the students' reasoning abilities when we discussed the different strategies they used while playing the games.

The unit for the third and fourth weeks involved batteries and bulbs. After much experimenting, all of the students had success with lighting at least one bulb and the interest seemed high. We went on in the next three days to provide the students with opportunities to work on parallel and series circuits, electromagnets, and other explorations of the students choosing. Both the student and teacher enthusiasm seemed to begin fading during these two weeks. It was nearly the end of the school year, and student attendance began to decline. Jayne and Suzanne continued to have debriefing meetings after each session and Tuesday meetings with Diana; but, we found ourselves spending less time and energy focusing on our teaching. We also noticed we were spending less time debriefing with the students after the class sessions. We could see the light at the end of the tunnel; we really wanted to make end-of-the-year preparations in our own classrooms. We let student interests and choices in activities slide and plowed along with our own agenda. We all knew that student ownership and involvement in their learning experiences are essential parts of good teaching, but even well-intentioned teachers can make this mistake when time and fatigue wear them down.

The chemistry unit, which is usually a huge hit and of high interest to students, seemed to drag on endlessly. By this time, the students were complaining about the amount of writing they were asked to do and wanted to spend more time on the computers so they didn't have to think. It was close to the end of the school year, and we were all ready for a break. We didn't want to put forth any more effort.

In the end, we probably should have known better than to try to run an after-school class so close to the end of the school year. We thought that the excitement generated from doing hands-on science activities would keep us all invigorated, but we had no such luck. We also felt the effects of a prescribed curriculum on student enjoyment in the learning process. Even though we planned activities that we thought would be of high interest to the students, they had no say in the matter, and their reaction was no surprise. Without some ownership in the learning process, students find school BORING!

The student and parent comments were, again, mostly positive. We both know that we have room for improvement in our teaching practices and in the way we deal with parents. Parents need to be informed about what we are teaching and the research behind the practices we employ. With hindsight and the wise words of Diana, we both realized that we should have communicated more with the parents, before their children started the class, about what our expectations for their learning would be. This preparation would have helped answer the types of questions parents had about the program as well as helped open a better line of communication. If parents don't understand what is happening in classrooms, how can they be supportive? We are also trying to learn to deal with the negative reactions that some parents will have at first to this type of learning. We cannot stress enough how helpful, necessary, and essential it is to have the support of a colleague in the change process. No one should have to go through this change in isolation.

Diana's thoughts about Session #2

Time is the important aspect of reflecting, and we teachers have no more time to spend. Even with the after-school program, reflection came at a price. The program ended at my dinner hour, one of the few times my family was all together during the day. For Suzanne and Jayne, it was the end of a VERY long day, and spending another hour or two was not a pleasant thought. But being dedicated, we bit the bullet and did what needed to be done. Was it worth it? YES! Without that critical component of reflective-collaboration time, we would have missed out on the collegiality and tremendous support we gave each other. It's the undescribable feeling that comes after a particularly grueling session that makes it worthwhile. The feeling of renewal and "I'm not in this alone" is what makes all this talk work.

WHAT DOES ALL OF THIS MEAN?

Jayne and Suzanne's Findings: The truth about innovation, or are we trainable?

We began this experiment determined to discover why it is so difficult for teachers to implement innovative programs in their own classrooms and to see if we could facilitate growth among learners of all ages (students and teachers). We felt that creating a safe learning environment would promote free exploration of new ideas and make those ideas easier to accept.

We discovered that, in our excitement to promote active learning, we were focusing on the wrong parts of the program. As we met the students who had signed up for the after-school program, we realized that willingness to participate was not enough. We needed some very well-defined and structured, requisite skills to go anywhere at all.

1. Students must be comfortable asking open-ended types of questions.
2. Students must have prior practice in decision making to be able to take over some control of their own learning.
3. Students must have the ability to work as a productive member of a team (cooperative learning skills).
4. Students must have experience investigating and exploring the world around them.
5. Students must have had enough play time (exploring tools and supplies) so they are ready to settle down and work. Students who had never spent much time with the tools of science—balance scales, measuring devices, etc.—were not ready or able to use them as recording tools.
6. Students must have experience in persevering through their frustrations. The world is filled with

> problem situations for which there are no readily apparent or right answers. Students who have experience dealing with multiple solutions to a problem will be better able to get ahead in the world of the future.

The above characteristics of a self-motivated, lifelong learner must be kept in the back of the mind of the facilitator of instructon at all times.

Diana's Findings (AHA!)

As we talked, it became clear that there was a theme to our conversations. What students were lacking was the same thing their teachers were lacking. How can students ask searching questions if their teachers are not asking such questions? How can students work well as a team member if they have not had a chance to be part of a team? How can they control their own learning if someone else does it for them?

AHA! Finally, we had found a common thread. Teachers must model learning behaviors and then allow their students to practice those behaviors. This means a major paradigm shift for teachers. No longer are they directors of learning, rather they must become facilitators of learning and collaborators in the learning process.

In order to make the paradigm shift, teachers must have opportunities to learn how to facilitate learning in their classrooms. Present staff development does not address this need. Staff development must provide teachers with examples and non-examples of what facilitation looks like and sounds like in a classroom setting. Staff development must give teachers time to be learners and time to talk and reflect about their learning. Staff development must not leave teachers after one or two sessions and assume that teachers, on their own, will now "do it right." Teachers need to be able to collaborate with others who are interested in the change process so they will continue to risk, grow, and learn. No one should have to face either success or failure alone.

THE FINALE

Unquestionably, the three of us feel we learned a great deal during this experience. We realized the value of struggling with the change process and concluded that collaboration, concerning the struggles, was essential. We also better understand that teaching process-science and problem-solving skills is difficult, even for those who believe in this type of teaching. For three people who thought we knew a lot about teaching science, we were all humbled by this experience. It is hard work to run a constructivist classroom, but, in the long run, we still believe it is worth the time and trouble. We encourage everyone to engage in the change process. Find a friend, struggle, reflect, feel success, but, most importantly, never give up and never stop learning!

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APPENDIX 1A

March 17, 1995

Dear Parents,

Today is the last day of the Quest After School Enrichment Program. The past six weeks have certainly been a time of growth and learning for Mrs. Morrison and myself, and we hope this is true for your child as well. I'd like to take this time to give you a brief explanation of the program and then describe what we hope we accomplished.

We started this program last summer and decided to try it as an after-school program after receiving requests from many parents. The idea for this program was founded upon several beliefs. We believe that ALL students should have the opportunity to learn science concepts, problem solving and math applications by actually exploring and experimenting with these concepts. We also believe that student achievement will increase if the school day and/or year are extended with activities that will expand the present curriculum and provide hands-on learning activities that are often difficult to fit into the present school curriculum.

We were surprised to find that two years after a district adoption of a hands-on science philosophy, many of the students had little knowledge of what science is, other than what you read out of a book. We both feel that students learn best by doing activities and then discussing and writing about them. As we worked through this session, we began to have a better understanding of the obstacles that prevent teachers from attempting this kind of active learning in their own classroom. Even though we scheduled 2 hours, we found ourselves constantly running out of time. Also the cost of materials, the mess, and the noise level certainly could make this kind of classroom unacceptable to some educators. We hope to eventually involve other teachers from throughout the district in training sessions so that we might facilitate more hands-on learning experiences in the regular classroom.

With these beliefs in mind, Mrs. Morrison and I came up with the following goals we hoped to achieve through this program:

1. To provide successful encounters with science that help students discover what they want, and are able, to learn.
2. To provide experiences that demonstrate how to transfer scientific and problem-solving skills to other academic or non-academic areas.
3. To provide a part (or another part) of the school week that is intellectually challenging and satisfying.
4. To develop workable curriculum units that might be used by other classroom teachers.
5. To develop students who are able to communicate about scientific and mathematical ideas.

During the past six weeks, the students have experienced a wide variety of problem-solving and scientific situations. We wanted to give the students a chance to explore many different scientific topics, so we did not get into great detail in any of the areas. It is our hope that the students will take some of this new-found knowledge and continue to research these concepts at home and/or in school. We have experimented with time and movement using pendulums the students built; we studied flight and the effects of wind and air pressure on flying objects; we worked with chemical reactions by mixing different substances together; and we talked about designing

prototypes for models of cars, boats, gliders, and big wheels. Studying Crystalology, using microscopes, and mapping activities rounded out the session. Again, it was a great (yet tiring) experience for us, and we hope your child has enjoyed his/her time with us. It is our hope that from these experiences, when the students read and hear more about these science concepts, they will have the background to help them understand and better apply what they learn.

Attached to this letter is an evaluation of the after-school program. Since this was the first time we have tried this type of program after school, it would be extremely helpful if you would take the time to fill out the form and return it to the Quest Office, P.O. Box 1089, Rock Springs, WY 82902 in the attached envelope. Thank you for your time.

Sincerely,

Jayne Hellenberg　　Suzanne Morrison

May 30, 1995

Dear Parents,

We had this letter written, but forgot to send it home with your child on the last day of the After School Enrichment Program. I'm sorry about the delay in this information.

We have found that the last nine weeks of school is not the most ideal time to run an after-school program. Between everyone's busy schedule and summer fever, this session wasn't as successful as we would have liked it to be. However, this has certainly been a time of growth and learning for Mrs. Morrison and myself, and we hope this is true for your child as well.

We started this program last summer and decided to try it as an after-school program after receiving requests from many parents. The idea for this program was founded upon several beliefs. We believe that ALL students should have the opportunity to learn science concepts, problem-solving skills and math applications by actually exploring and experimenting with these concepts. We also believe that student achievement will increase if the school day and/or year are extended with activities that will expand the present curriculum and provide hands-on learning activities that are often difficult to fit into the curriculum. Along with these beliefs, current research in elementary science education stresses that students should learn science process skills through experimentation, discussions, and making conclusions about the world around them from their own experiences. Then, with many varied experiences, learning content science in the secondary years should become easier.

With these statements in mind, Mrs. Morrison and I came up with the following goals we hoped to achieve through this program:

1. To provide students with an opportunity to observe and explore the world around them. (Not all science and math concepts must or should be learned from a book).
2. To provide a chance for students to be involved in experiments, problem solving, discussions, and writing. This practice should help students develop the ability to communicate about scientific and mathematical ideas.
3. To provide a part (or another part) of the school week that is intellectually challenging and satisfying.
4. To develop workable curriculum units that might be used by other classroom teachers.

During the past six weeks, the students have experienced a wide variety of problem-solving and scientific situations. We wanted to give the students a chance to explore many different scientific topics, so we did not get into great detail in any of the areas. It is our hope that the students will take some of this new-found knowledge and continue to research these concepts at home and/or in school.

We worked with Earth Science during the entire six week period. The students picked field sites, in the field next to Desert View, to practice observing, recording, measuring growth over time, and

experimenting with rocks and soil. We visited the field sites at least once a week (when the weather permitted) to get an up-close view of nature. We also spent the first two weeks of class talking about and designing structures. The students learned how much time, planning, and organization it takes to design a sturdy structure when they tried to built a model biosphere into which their group of scientists could fit. From structures, we moved on to experiments with electricity and magnetism. The students were involved in creating circuits and electromagnets, along with several other activities. The last two weeks were spent touching on kitchen chemistry. We learned about the behavior of different liquids and the difference between a chemical and a physical change.

Again, it was a great (yet tiring) experience for us, and we hope your child has enjoyed at least some part of his/her time with us. It is our hope that from these experiences, when the students read and hear more about these science concepts, they will have the background to help them understand and better apply what they learn.

Attached to this letter is an evaluation form for the after-school program. From now on, we are planning on running a summer program only, and are looking to make any changes that would make this program more successful. In order to plan for the summer sessions, it would be extremely helpful if you would take the time to fill out the evaluation and return it to the Quest Office, P.O. Box 1089, Rock Springs, WY 82902 in the attached envelope. Thank you for your time!

PARENT EVALUATION FOR AFTER SCHOOL ENRICHMENT PROGRAM

Was this program beneficial to your child? Why or why not?

Can you think of any changes that would help us make this program more successful?

Would you be willing to have your child participate in this type of activity again? If so, do you think after school, summers or both would be appropriate?

Do you feel the 24-hours of instructional time was too little, too much, or just right?

STUDENT EVALUATION FOR AFTER SCHOOL ENRICHMENT PROGRAM

What did you like about this class?

What did you learn?

What things do you wish you could have done differently?

Would you like to take another class similar to this? Why or why not?

WHO'S SUPPOSED TO MAKE THE DECISIONS IN THE CLASSROOM ANYWAY?

Lorrain Rudd

TABLE OF CONTENTS

WHO'S SUPPOSED TO MAKE THE DECISIONS IN THE CLASSROOM ANYWAY?

This study investigated how much poorly motivated students could improve their academic success if a teacher allowed these students say in how objectives were taught and assessed. Quality of work, assessment scores, and participation remained the measures of academic success. Seven students, considered poorly motivated, were followed during the school year to determine if the change in teaching style had affected their academic outcome. While there exists some evidence to that effect, a small percentage of students need time to decide that they want to learn and to perform tasks requested of them. The data have also forced bigger questions: a) What is success, what is learning? b) How can we give students accurate feedback? c) How influential can a teacher be in reducing the time a child needs to make decisions concerning his/her learning and performance?

INTRODUCTION

I have attended workshops, in-services, and classes, and read a great deal of literature in the last several years describing how teachers should conduct their classrooms to motivate middle-level students to be successful. Much of the information was based upon some educational fad. Educational fads have their place in our business: Without them, educators might be unwilling to try new ideas that could lead to better ways of teaching. However, some fads developed and promoted at a university level without teacher input, ignore the uniqueness of each school district's employees, student population, and local culture. Unfortunately, then, many fads are useless, either in part or in whole. In addition, many educators are not very well versed at picking and choosing those parts of each fad from which they might benefit because they are presented as in-services without follow-ups. It's no wonder that after following these magical recipes for student success, including a quality curriculum (Glasser, 1992), year after year, 5-10% of the seventh graders who travel through my general science doors are not successful—they do not pass science. I was troubled by this nearly predictable outcome and wanted to know why it was happening and what I could do to change it.

The "fad" which this research represents, teacher-directed inquiry, promotes the teacher as researcher through collaboration with peers. The research is supported with the acknowledgment and use of the theoretical data which comes from my predecessors. However, for the first time I could rely primarily on the data I collected on my students, making it 100% applicable and meaningful to my particular set of circumstances—my unique students in my unique classroom in our unique school population and community.

Initially, my team of three researchers set out to measure the effects of giving poorly-motivated students a say in how they learned. My two peers were unable to continue with the project, so my collaboration became limited to monthly meetings with the other teams of collaborators who were working on their own studies.

I initially intended to focus my research on the needs of seven students, but, through the collaborative process, I began to think in broader terms. This report includes findings and some conclusions on what I learned about and from all my students.

BACKGROUND AND RESEARCH SITE INFORMATION

I am Lorrain Rudd, and I conducted this research during my fifth year of teaching. The 1994-95 school year was my second year of

teaching general and physical sciences to seventh and ninth graders respectively, at East Junior High School, Rock Springs, Wyoming. I have a BS in zoology and BA in French from Eastern Illinois University and a BS in secondary education and an MS in zoology and physiology from the University of Wyoming.

One of two junior highs in Rock Springs with a traditional structure, East enrolled 723 seventh- through ninth-grade students during the 1994-95 school year. Twelve percent of the school population was listed as academically disadvantaged, 15% were eligible for free/reduced lunches, and 13% of the students were non-white. The student population represents predominantly middle-income families. East Junior High spent an average of $236 per student, minus employee salary and benefits.

Research was conducted on three sections of general science for a total population of 60 seventh graders, of varying academic ability. All seventh graders are required to enroll in general science, and if they fail, they are required to repeat the course as eighth graders. In order to graduate from East Junior High, students must earn two credits of science. Earning a letter grade in science is based upon the traditional percentage scale. In general science, I divided the school year into two parts, earth and life science.

The seven students who became the subjects of this research were all seventh graders, four girls and three boys. One boy is Hispanic, the rest are Caucasian. Three of the seven were in one section of general science, two in another, and two in a third. Three of the students were enrolled for at least a part of the school year in our behaviorally and emotionally at-risk (B.E.A.R.) program. This program also accommodates any student who may not have qualified for special education services and/or is deemed academically "at-risk," usually by faculty or counselors. Students enrolled in B.E.A.R. devote one class period per day to working more closely with the B.E.A.R. aide in the discipline(s) which is (are) the most challenging to them.

My subject students never willingly participated in class (such as in review sessions, note-taking, or any cooperative group/project work) and seemed quite content with either not completing assignments or providing very poor-quality work. I contacted the students' other core subject teachers (Cochran-Smith and Lytle, 1993, p. 160) to solicit information about instructional techniques they had used successfully with these students. Unfortunately, when asked what they do in their normal, daily teaching that helps these seven be academically successful, they supplied no information. These seven students were in academic jeopardy in other classes as well. Encouragement, words of praise, increased one-on-one time in the classroom, and increased written feedback on any work that was turned in seemed to have no noticeable effect. These students seldom came to class with paper or pen, and sometimes provided behavioral distractions for those sitting near them. The four girls seemed to be very social, having many friends, while the three boys seemed to have few friends.

RESEARCH PROCEDURES

Fall Semester, 1994

Teaching began on a fairly traditional note, featuring the teacher in the spotlight. I presented the students with notes in outline form to be copied into their notebooks, and I encouraged discussion during lectures. I also provided the students with some type of hands-on activity and follow-up questions to be answered, or I presented a video and/or film. Occasionally, I assigned worksheets or related reading.

I taught units including the rock cycle, geologic time, changes on earth, map reading, and the moon. Also, as part of our district's curriculum, I incorporated graphing, lab techniques, the scientific method, and metrics into as many units as possible. In short, I made all decisions on how to best help the students learn the objectives. My decisions were based on my perceptions of successful lesson

plans implemented in the past, revising and fine-tuning as necessary year after year.

During the first semester I identified those students who were not passing science, and I contacted the parents of these students in an attempt to solicit their encouragement for their children (Cochran-Smith and Lytle, 1993, pp. 229-230). Some of these students did not remain in my class for a variety of reasons. The seven students who remained in my classroom for the entire year were the subjects for this research during spring semester.

Spring Semester, 1995

During the second half of the school year, I taught units including the solar system, weather, cell/life features, genetics, evolution, ecology, and classification. I told my students that I was taking a college course, and the goal was to figure out what we could do to make learning science better for them. In addition, I told them my problem and hypothesis (since they had already been exposed to the scientific method) that if I allowed them some input into how class was to be conducted, science would become easier to learn and more fun, and maybe some who didn't like science would enjoy it more.

During the second one-half of the school year, the students made many of the classroom decisions. I conducted an informal, oral survey at the beginning of each unit. This survey consisted of two questions addressed to all 60 students, "These are the objectives you need to learn. How do you want to learn these, and how do you want me to assess this learning?" (see Appendix 2A, p. 36) Students would then brainstorm ideas of how to best learn the objectives or assess them. Initially, this took two to three class periods with only a few students participating, but by the end of second semester, brainstorming sessions were completed in one-half to one class period with at least half the students taking part. If students couldn't agree on how to learn objectives (though they usually could), we went with majority rule. I encouraged discussion beyond the brainstorming sessions into the context of the unit as well. In short, a dialog was established that I hoped would bring students out of their shells and actively involve them in their education.

At the end of second semester, I reevaluated the quality of the seven's work, the number of assignments they completed, and their level of participation as measured by the number of times they joined in during review sessions, took notes, and/or meaningfully contributed to cooperative group/project work by being on-task. I also conducted an interview with these seven students and with all general science students at the end of second semester in an attempt to shed additional light on my findings and conclusions (see Appendix 2A).

FINDINGS

When students were allowed to decide how to learn objectives, they selected a variety of methods which varied depending on the unit. How students wanted to learn curriculum objectives was divided into six basic categories. In order to learn all the objectives associated with a unit, students found they needed to choose from three to five of the following:

1. Every-other-day reviews. Specifically, they wanted me to randomly call on them using the notes, posing questions. Often, they wanted to get a partner and quiz each other. Sometimes, they turned it into a game, jeopardy-style.
2. Videos and films.
3. Some reading (not too much)/library work.
4. Projects. They chose being put into groups of one to four for all project work.
   - I selected the groups of four for the solar system project, making sure my seven students were in groups in which they could

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both contribute and benefit. I made sure the group could function effectively even if my targeted student choose not to participate. For this unit's project all groups chose to build a three-dimensional replica of the solar system and make an oral presentation explaining their model.

- The students picked their own groups of four for the weather unit project. For this project, all groups wanted to make a model of the seven types of clouds they were responsible for learning and present a one-page paper accompanying the model which described the clouds' shapes, altitude, and associated weather.
- For the evolution project, most students chose to work alone. Some, however, worked in groups of two or three. Each group wanted to work on the topic of its choice. Most did a poster associated with the evolution of man accompanied by an oral and/or written report. Often, the group work would include reading/research done in the library.
- For the ecology project, the students asked that I tell them what to do but give them the freedom to complete it the way they chose. The project was called, "Making A Place for Wildlife." Students were given ten species of animals for which they illustrated homes by creating posters, sketches, collages, or dioramas.
- For the classification unit they again wanted me to assign a project, but, since it was the end of the school year, they requested that it not be too time-consuming. I gave them a choice of eight projects. They included a) classifying 14 species into the correct kingdom on a chart; b) classifying county, city, country, house number, continent, street, then comparing to one of the seven groups used in the natural science classification system; c) identifying and justifying which two of three given species were more closely related: Quercus alba, Salix alba, or Q. rubra; d) describing why, for example, the following are confusing: starfish, seahorse, horseshoe crab, reindeer moss etc.; e) classifying objects that are found in their closet; f) hypothesizing how the development of the compound microscope affected the classification of living things; g) explaining why a wolf and fox cannot interbreed, while a German shepherd and a cocker spaniel can; and h) explaining why scientists don't classify animals by where they live.

5. Notes, which were to include pictures, given to them by me.
6. Hands-on/experiments.
   - For the weather unit, students wanted to do an experiment which would show them how temperature, pressure, and cloud formation were related. In the cell unit, students requested to look at the various stages of mitosis in cells under a microscope and to make drawings of the stages which they would incorporate into their notebooks. For the genetics unit, they wanted me to make a worksheet to practice using Punnet Squares. We also created people with fake traits, some of which were dominant, some recessive.

As we entered each unit, took notes, watched the film or video, or moved on to other methods they chose, students quickly realized the problems that existed with that particular mode of learning and made revisions. For example, "That movie covered only objective #3! We're going to need something else for objective #4!" Or, "Our group can't do this kind of project. We've looked in both libraries, and we can't find the kind of information we need. May we change?" While this type of conversation was slow in coming (I did not hear it until second semester), when it did come, I felt, for the first time, that most students were actively involved in, and felt some responsibility for, their own learning (see Table 1).

When students were allowed to decide how to have learning objectives assessed they selected the following:

1) Projects graded by me.

- For the solar system and weather projects, I asked students how they would like to have the projects assessed. Figure 1 represents the checklist the students and I produced from the items students felt should be present on the project. Each check was worth one point toward the total grade.
- For the evolution project, a total of 50 points could be earned, but because the individual projects varied, a percentage system was used (see Figure 2). The students and I agreed on what was important and then assigned a percentage of the points to different aspects of each project. For some, artwork was important while for others grammar and spelling were vital. Oral presentations and posters were also deemed crucial for some. All agreed that content would be central to all projects.

Table 1
STUDENT SELECTION OF LEARNING TECHNIQUES FOR EACH OF THE UNITS TAUGHT

Unit	Reviews	Video/films	Reading	Group Projects	Notes	Hands-on
Solar System	X	X	X	X	X	
Weather	X	X		X	X	X
Cell/Life Features	X				X	
Genetics	X		X	X	X	
Evolution	X			X	X	
Ecology	X	X		X	X	
Classification	X	X	X		X	

X indicates the learning technique was selected by the majority of the 60 students as a means by which they wanted to learn the objectives.

Figure 1
SOLAR SYSTEM PROJECT CHECKLIST

Mercury

____ craters
____ hot/cold
____ solid

Venus

____ clouds/hot
____ greenhouse
____ solid

Earth

____ life
____ one moon
____ solid

Neptune

____ two moons -
Titan
____ gases

Pluto

____ solid
____ one moon
____ cold

Mars

____ red
____ ice (caps)
____ two moons
____ solid
____ river beds
____ canyon
____ volcano
____ craters
____ sand dune

Jupiter

____ hot
____ Red Spot
____ clouds
____ 16 moons
____ 10 - volcano
____ rings
____ gases

Uranus

____ tilted
____ > 15 moons
____ five rings
____ ice/rock core
____ clouds
____ gases

Saturn

____ rings
____ 23 moons -
Titan
____ gases

Additional Features

____ asteroid belt present
____ Oort Cloud present
____ correct location of objects
____ sizes correct
____ spacing distances correct

Average group grade = ____/5
Project grade = ____/30
Total Score = ____/35

Figure 2
WEATHER PROJECT CHECKLIST
(CLOUDS)

	cumulus	cumulonimbus	stratus	nimbostratus	cirrus	fog
shape						
color						
altitude						
weather						
why develops						

project grade ____/25

+ group grade ____/5

= total ____/30

- For the ecology projects we decided it would be simple. Either they incorporated shelter and something to eat and drink for each species of animal, or they didn't. Out of 25 points, they wanted me to remove one point each time one of those components of the habitat were missing.
- For the classification projects, students asked me to grade them any way I wanted. It was the last week of school and students were experiencing "burn-out" on decision-making.

2) Traditional paper and pencil test, when necessary, when objectives weren't addressed by projects.

3) Teacher-graded answers to questions associated with daily work on all units, such as hands-on activities and worksheets associated with films and videos. Grading such work was done in a traditional manner.

4) Grading each others' projects anonymously.
   - Students felt that the teacher wasn't the only one who could give useful feedback to a student when grading a project, and they wanted to give feedback to each other as well. In order to grade peers on the solar system project, they developed a crude rubric system. For each project, students rated each other on a scale of 1-5, with 5 being outstanding. For each unit we discussed what an outstanding project was, what would be lacking for a 4, 3, etc. This varied from project to project. If they graded any of their peer's projects with something other than a 5, they explained why on paper, citing at least one of the characteristics of what we thought would be a 4, 3, etc. I collected the papers and averaged scores together. If these features were present, I simply put a check on the line. Students were to include no fewer than 30 features for the solar system and no fewer than 25 for the cloud project.
   - For the weather unit, and all following ones, they repeated the same evaluation procedure. After the solar system unit, they decided they wanted the evaluations returned to them because they felt that they wouldn't know what they did wrong if no one in the group told them. We discussed how to say things nicely so feelings are spared, and how to be diplomatic in developing good public-relations skills. They were learning how to give useful feedback. I observed students were often more harsh on each other than I would have been. Any fears I had of expectations declining by letting students take charge soon dissipated.

By the end of second semester all graded work for the seven students averaged 38-70%. Five of the seven students became very enthusiastic about participating in group/project work (see Table 2.) The other two didn't carry their load when working in teams and forced everyone else in the group to pick up where they slacked off. Of these five, three took notes and produced higher-quality work. Four of the seven students willingly and meaningfully participated in review sessions. Of these four, two improved their grades simply by taking fewer zeroes from assignments not handed in. Only one student didn't improve upon any aspect of first semester.

During first semester, all seven students chose not to exhibit any of these five indicators of positive learning engagement. All of their graded work averaged 41-61%. Sometimes individual assignments were completed, but never all assignments. The students never took part in review sessions or took notes, and never willingly participated in any type of cooperative-group learning.

At the end of second semester I interviewed six of the seven students (see Appendix 2B, p. 40). Student 7 refused to participate in the interview. When asked if they liked first or second semester better and why, all six students said they liked second semester better because it was more interesting, which, according to the students, meant it was easier. When I asked students how interesting was synonymous with easier five said that trying to learn boring material is hard because they can't concentrate on it enough to learn. If it's

Table 2
ATTITUDES AS REFLECTED BY QUALITY OF WORK, PARTICIPATION, AND DAILY WORK SECOND SEMESTER 1994-95

	improved quality	all work completed	reviews	notes	group work
Student 1					
Student 2	X		X	X	X
Student 3	X		X	X	X
Student 4					X
Student 5	X	X	X	X	X
Student 6		X	X		
Student 7					X

X indicates which aspect of learning students exhibited.

interesting, it's easy because concentrating is not a problem. Because they were allowed to determine how to learn, the material became more interesting and thus easier for these students. Four of the six added that the more frequent reviewing also made the content easier.

Five of the six indicated that a "significant other" in their lives (an uncle, a counselor, and for three, a parent) made a difference second semester.

When asked, "What could Mrs. Rudd have done differently, either sooner or throughout the year, to have made science better for you?," four said there was nothing because they were just not ready to learn. When I asked the students what "ready to learn" meant, they answered, "wanting to do the work," "making school more important than my friends," "wanting to stop screwing around," "being motivated enough to help myself," and "wanting to pass badly enough." That, of course, begs the question how do we motivate students, not just to learn science objectives, but to want to learn at all—the focus for another project!

Finally, 83% of all general science students (n=52) said they liked making decisions in the classroom, 2% did not, and 15% said they could take it or leave it. When asked if making decisions helped them learn the objectives better, 87% said making decisions helped, and 13% said it did not. Although it was not my focus for this research, the grades of all other students either went up or stayed the same.

ANALYSIS, INTERPRETATIONS, AND SOME REFLECTIONS

Almost every conclusion drawn in this research relies heavily upon the opinions of students. This method of research needs careful consideration when examining the answers to the questions

conducted during the student interviews. I question the sincerity of some of the answers given by at least a few of the students. For example, Student 4 told me I assigned too much homework, and, any homework assigned, I should have done with them in class so they'd understand it better. I assigned an average of 1.3 homework assignments per two weeks during first semester and .8 assignments per two weeks during second semester. The same student also said I didn't give her enough time in class to complete tasks. Although she said that coming in before or after school to complete them was not an option, I later discovered that she was allowed to stay after school. While I believe most of the answers given by the majority of students to be sincere, I think it's sometimes difficult for a child to give a teacher any negative comments when in a face-to-face situation, no matter how much they are encouraged. There is also evidence to suggest that young students may be unable to access higher order cognitive processes (i.e. people are unaware of a stimulus and/or that a stimulus has affected a response, Nisbett and Wilson, 1977). In other words, students may be unable to determine why they did or said what they did when interviewed at a later point.

Because most of my students have received 7 1/2 years of traditional schooling, it is not surprising that they choose fairly traditional methods for training and assessment. The students feel comfortable with these methods and may be unaware of the methods' shortcomings for measuring learning.

The checklist was a real break from traditional method that evolved out of brainstorming sessions. It was also the method by which the students evaluated each other. Perhaps more can be done with those new opportunities.

The seven target students, as well as the majority of the students, were very enthusiastic about being involved in the planning stages of the units. I was impressed with the variety of learning styles they seemed to want and need, from class notes and films to projects and hands-on experiments. Other authors have also found students would rather have an active role in the classroom (Phelan, Locke Davidson, and Thanh Cao, 1992) and that students learn best when they have choices and power over how they learn the curriculum (Mamchur, 1990). It's also documented that learning is facilitated if it is interesting, relevant (Hootstein, 1994), and if what is to be learned is of high quality (Glasser, 1992). All the students interviewed confirmed these ideas when they agreed they liked making decisions on how class was conducted. The variety of teaching and learning strategies obviously helps students learn more effectively and helps motivate the hard-to-motivate student because learning environments that are less boring and stressful translate into learning situations which are more fun and engaging (Curwin, 1994; Theobald, 1995).

Five of the target students were my only general science students not to receive credit for the class. I do not believe the class was too difficult for them. In fact, five of the interviewed students actually said science was, to some degree, easy. Four of the six said the frequent reviews they requested, and the opportunity to make decisions on how learning was to take place, helped them learn better. Even though they all said they enjoyed second semester more, five still did not pass the class.

I believe students will not learn very well if they can't make choices, or if the learning isn't interesting and relevant. Four of the six said science was interesting. Unfortunately, I did not ask the students questions pertaining to relevancy. The five students who did not receive credit told me they chose not to do well for a variety of reasons, and four said there was nothing I could have done to help them at any time. Perhaps as teachers we need to think about what students perceive their choices to be, and how we might address their needs as learners. I believe my seven students needed something other than interest, relevancy, and a feeling of ownership for their education to be truly successful within our current educational system.

It was mentioned by a couple of the students that they weren't ready to learn. Though it's possible they see no benefit to learning, I believe they need time to decide they want to learn and time to perform and complete the tasks asked of them. The 45-minute class period in science may not be long enough for some students. What are the implications since 45 minutes per day for nine months is the schedule? We still must accommodate their needs. Exposing students to good teaching (allowing them choices, frequent reviewing, making learning interesting and relevant, and keeping expectations high, for example) is what 90-95% of our student population needs. The other 5-10% have those needs in addition to others. We must respect and accept their need for time, and realize that the time may not come during the nine months under our care. We need to invite and welcome them, while still giving these students their space. I think modeling patience and acceptance can go a long way.

Can a teacher be influential in reducing the amount of time a child needs to decide (s)he wants to learn? While I believe it's possible, chances are reduced when we are exposed to a child for only 45 minutes per day for nine months. It wasn't until June 1 that I began to understand the needs of those seven special students. Realistically, working in an educational system in which 150 students pass through my doors each day averages out to 1.8 minutes of my time per student per day. For a student who I believe needs time and space, 1.8 minutes per day of my time certainly makes being that significant other rather challenging. The parents' roles, therefore, are very important. Five of my six students mentioned a significant other in their lives who made a difference when the student was doing better in science. The need for at least one adult to be positively involved in a child's education is also well documented (Anthony and Cohler, 1987).

While parents need to understand that, ultimately, only students can make themselves successful, parents themselves and good teachers and teaching go a long way toward encouraging and rewarding students to be successful. I know parents can be extremely influential in reducing the amount of time a child needs to decide he/she wants/is ready to learn. If their child is one of the unsuccessful 5-10%, and they find it difficult or impossible to influence their child's learning success, parents must know we all should respect the child's need for time, even if it means not earning credit for a class. An essential job of educators is to creatively involve parents. Data show that parental involvement is inversely proportional to the age of the child, making this a particularly challenging task as students get older.

Even though all students told me they liked making decisions, I doubt students want complete control of their learning. Students usually asked me to make the decision about what's important to know. Students asked me to conduct some of the review sessions and to construct a genetics worksheet because they were unsure of what was important. Also, students asked me to decide what the ecology and classification projects would be. The ultimate indicator of being reserved about taking sole responsibility for learning is the fact that students requested note-taking. Students hate taking notes! Again, I believe they were asking me to decide what was important, and pass that information on to them.

Although the students enjoyed making decisions, perhaps they weren't comfortable with the concept of the student as decision-maker because we haven't allowed them to make decisions. For over seven years they were told that the teacher was solely in charge. Students need modeling and practice in making decisions which will ultimately allow them to take responsibility for their own learning. Students may also be telling me they want to develop a culture of sharing in the classroom—a partnership with me. A collaborative atmosphere can invite students to assume ownership of the curriculum (Cone, 1992).

It is possible that the students were concerned with those detailed, nit-picky questions that they knew would be found on a traditional, multiple-choice, fill in the blank, true-false test when they asked me to be in charge of their learning. If I am going to allow students

the freedom to learn objectives in ways they choose, then I need to consider and assess what students will learn along the way. This thought brings me to the concept of learning and success being individualized (McNamee, Varcalli, 1994). As a teacher, can I accommodate 150 unique learners? Is this why five students did not pass general science? And what is success? Four of the six students told me learning was easier, better, more interesting during the second semester, so they believe they learned.

Maybe I didn't ask the right questions, those questions that would get at what they really learned, what would have made them successful. Perhaps alternative, but appropriate means of assessment, would be in order.

As I reflect on the thought of accommodating 150 uniquely different students, I want to pull my hair out. Allowing students to assess each other and learn public-relations skills, allowing students to reevaluate their choice of learning strategies, and allowing them to collectively develop assessment tools—like rubrics—takes extra class time. The quality versus quantity discussion surfaces. While I think most educators will agree that quality is more important, quantity needs to be considered. We may also need to evaluate the quantity of **what**: For example, our general science curriculum theoretically consists of spending one-third of the year each on earth, life, and physical science. By using this new way of teaching (letting students have a say), I did not have enough time for any of the physical science content.

We may also need to think about what grades actually measure. Is it merely task completion? Is that what we want? Do students realize this? Are we measuring a student's knowledge? With the exception of Student 1, the students who were subjects for this research improved in at least some aspect of the second semester. Of the five who did not pass, one improved the quality of her work, one turned in all assignments, while all participated in more reviews or group work or both. For those five students, second semester was not a total failure. Unfortunately, too much of their work was entered into the gradebook as a zero because it was not completed; while task completion is important, these students are not failures as their "F" tells them. It's possible for them to earn an "F" in task completion, but it is not accurate feedback to call their second semester a learning failure.

How can a student grow without proper feedback? Since accurate feedback is characteristic of good teaching (Wiggins, 1993), we all need to be more creative, and find ways to give students specific feedback concerning all areas of their academic and non-academic progress. A letter grade cannot do a complete job. If a child needs time, and I would like to be influential in reducing the amount of time a child needs, I need to make sure the student knows exactly what he/she is doing well or poorly. Good decisions are not possible without accurate information. In order for me to give accurate feedback I return to the idea of alternative, but appropriate, means of assessment. The dilemma I'm faced with again is finding such a means for 150 unique students.

So what will I do with this information from a practical standpoint? Since enthusiasm and performance were markedly higher among all my students second semester, I will begin the new school year with the students' input. From my observations, any student can only benefit from becoming more responsible for what he/she learns in the classroom. Because I think students need time to get used to the new way of teaching (and I do, too!), I will begin by making all decisions with the first unit, modeling as much variety as possible. With the introduction of the second unit I will solicit students' opinions on how to learn objectives, and I'll make the rest of the decisions. At the beginning of the third unit, not only will I ask students how to learn objectives, but how they should be assessed. Little by little, I will ask them for more input until we have reached a happy median in our culture of sharing. I believe students will need some time to learn to trust me, and each other, so that constructive and accurate feedback is possible.

I know chances are that I will still have a few students who will not be ready to learn. I will continue to probe for different ways to reach one or two more, learning along with the students. As is always the case when dealing with humans, the answers are never simple, never black and white. There is not one "magical recipe" for making students successful. Indeed, students cannot be forced to be successful.

This research has taught me that I can relinquish control of the classroom to the students while still providing them with guidance. Expectations do not have to suffer and quality can remain high. I have also learned how rich and rewarding it can be to learn with and from the students. While I firmly advocate teachers being extremely well-versed in what they teach, it's all right for teachers to let their guard down, literally get next to a student, and learn with them. I don't have to have the last word on any topic.

Unfortunately for me, the collaborative process was not as rich as it was for the other teams who participated in this project. Continued motivation for the other teams came from not being in this alone, relying on their peers to complement and supplement knowledge gained, and hurdling obstacles encountered in the research. While I also looked forward to collaborating once a month with the other teams, motivation for me came from the prospects of being able to make a difference in the lives of a small percentage of students, making changes in my classroom based on facts specific to my set of circumstances. I have no doubt this research could have been enhanced with the addition of a collaborator, for many of the ideas expressed above came from teachers who were part of a different team.

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APPENDIX 2A

UNIT OBJECTIVES

EARTH SCIENCE OBJECTIVES

Geologic Time

1. Describe the major events of each geological time era.
2. Relate geologic time to a smaller scale.
3. Define the geologic time scale.
4. Graph major geological time events on a time line.
5. Describe how the geologic time scale is subdivided.
6. List the 4 eras in the geologic time scale.

Changes on Earth (Plate Tectonics)

1. Define continental drift.
2. Define Pangea and explain what it has to do with continental drift.
3. Diagram the relative ages of rocks that made up the seafloor outward from the mid-ocean ridges.
4. Define seafloor spreading and explain how magnetic surveys provide support for this process.
5. Define plate tectonics.
6. Recognize evidence supporting the plate tectonic theory.
7. Compare and contrast divergent, convergent, and transform fault boundaries.

Weathering and Erosion

1. Recognize basic weathering and erosion.
2. Contrast weathering and erosion.
3. Describe physical and chemical weathering.
4. Explain the important factors that are part of the weathering process.
5. Identify some results of weathering.
6. Define runoff and sheet erosion.

7. List ways of reducing sheet erosion.
8. Describe how running water erodes.
9. Describe features of erosion and deposition by running water.
10. Describe the stages of landscape development, from youth to old age.

Rock Cycle

1. Describe the rock cycle.
2. Diagram the rock cycle.
3. Classify rocks as igneous, sedimentary, or metamorphic.
4. Describe how sedimentary rocks form.
5. Name the process by which rocks become metamorphosed.

Map Reading

1. Define topography, contour lines, contour interval, bench mark, scale, and legend.
2. Describe how elevation is shown on a topographic map.
3. List 5 general rules of contour lines.
4. Identify various features on selected topographic maps.
5. Read and interpret a topographic map.
6. Recognize the major landforms of the United States.

The Moon

1. Describe the relative motions of the earth, sun, and moon and the moon's effects on earth.
2. Describe the phases of the moon.
3. Explain eclipses.
4. Define umbra and penumbra.

Solar System

1. Describe the order of the planets in our solar system.
2. State the contents of the solar system.
3. List the inner planets.

4. Identify important features and characteristics of the inner planets.
5. List the outer planets.
6. Identify important features and characteristics of the outer planets.
7. Define comet, Oort Cloud, and asteroids.
8. Distinguish among meteoroids, meteors, and meteorites.

Weather

1. Recognize various weather patterns.
2. Recognize various weather measuring instruments.
3. Identify atmospheric factors that influence weather.
4. Describe how the earth's atmosphere is heated.
5. Relate air density to air pressure.
6. Describe the forms of water vapor in the air.
7. Classify air masses.

LIFE SCIENCE OBJECTIVES

The Cell

1. State the function/criteria that constitute the features of life.
2. Recognize living and non-living items.
3. Distinguish between plant and animal cells.
4. State basic functions of cell organelles.
5. Relate the importance of chromosomes.

Genetics

1. Know the difference between mitosis and meiosis.
2. Demonstrate how traits are inherited and expressed.
3. List the steps in, and describe the process of, mitosis.
4. Define a gene and discuss how genes affect traits.
5. Differentiate between sex cells and body cells.

6. Describe the process of meiosis and relate it to the formation of sex cells.
7. Describe Mendel's experiments with pea plants and explain the difference between dominant and recessive traits.
8. Discuss how Punnett squares are used to predict the results of crosses.

Evolution

1. Be familiar with the concept of evolution.
2. Describe the concept of natural selection.
3. Discuss the theories of the origin of life.
4. List the 3 major sources of evidence for evolution.
5. Compare and contrast homologous and analogous structures.
6. Explain how the fossil record can be used to study human evolution.
7. Discuss how Darwin's theory of natural selection can explain how new species are formed.

Ecology

1. Distinguish between populations and communities.
2. Define the various roles of organisms in a community.
3. Recognize biotic and abiotic factors in the environment.
4. Describe food and energy relationships within an environment.
5. Define a food chain and explain its relationship to a food web.
6. Design an energy pyramid of organisms.

Classification

1. Identify the 5 kingdoms.
2. Name the levels of classification in order.

Environmental Science

1. Be aware of local, national, and global environmental issues using current news-related material.
2. Recognize possible solutions and prevention measures for environmental problems.

APPENDIX 2B

INTERVIEW (QUESTIONS AND ANSWERS)

Question 1: Did you like first semester or second semester better or neither? And why?

Student 1: He liked second semester better because the life science part of general science was more interesting, especially the evolution unit. Since it was more interesting, he paid attention more and found out he understood more. When it wasn't interesting (first semester), Student 1 would rather socialize in class because it was more fun. He also liked being part of deciding how the class was going to learn things. He thought this made learning easier, and activities that students did made Student 1 understand the material better because students showed each other.

Student 2: Student 2 liked second semester better because it was easier and that made it more fun; however, she said she liked earth science better (which was primarily taught during first semester). It was easier because students made their own decisions about what they did. She especially liked the activities when I did them because it was clearer. Student 2 said it also helped her when we reviewed more frequently.

Student 3: Student 3 said she found second semester more interesting because "you started teaching differently." Student 3 thought that when I let students learn according to the students' opinions, it made the material easier to understand. Even though Student 3 did better in every aspect second semester, it was interesting that she found second semester harder because she thought the projects were more complicated and detailed. She also liked participating in the Science Fair. It was also during second semester that her uncle got involved in education. All this combined made Student 3 want to do better and pass. She said she studied second semester and her improved attendance during second semester made it possible for her to succeed.

Student 4: Student 4 liked second semester better. It was easier because students made their own decisions and decided to do more projects which made it more fun. She also liked the frequent reviews. About both semesters, Student 4 liked when I slowed down during note-taking time, offered the opportunity to do extra credit, gave students more time after school when they wanted to finish something, and gave students weekly, computerized progress reports.

Student 5: Student 5 liked second semester better because he did better in all respects. He liked coming in after school second semester because he needed more time and help, and that help increased his level of understanding. He paid attention more which made him like and understand science better, so he found it more interesting and even pretty easy. He said science was easier to understand when he paid attention. Student 5 liked doing more reviews in class as well as doing what the kids decided they wanted to do. During first semester he found it cool not to listen. His friends were not doing any school work in their classes, and their parents didn't say anything to them. Student 5 thought he could get away with it, too. All privileges, however, were lost at home. Second semester he decided he wanted his mother to be proud of him and to reinstate his privileges. He said he found out it was better to get good grades.

Student 6: Student 6 liked second semester. He liked the solar system and evolution units. He said it was hard to tell if he liked class first semester because he just screwed around then. All the activities the class did second semester made it interesting. He also liked making decisions on how class was conducted. Student 6 was placed in our school's "B.E.A.R." program second semester. He felt this also made a difference.

Question #2: Why do you think you haven't done well in science?

Student 1: "I came from California where my brother earned mostly F's in school and graduated anyway." He thought he could do the same. Then his father pointed out (during 4th quarter) that Rock Springs isn't like California and, here, we retain students when they don't pass.

Student 2: She said she always did badly first semester and believed, until it was too late, that she could continue to goof off and fix her grade later. She found notes boring, so tuned out.

Student 3 and Student 5: (question not applicable)

Student 4: "I could have done better if I had taken notes, done my homework, and studied. It wasn't until 4th quarter that my parents said I had to improve because my grade was too low." Student 4 was afraid to raise her hand in class and couldn't come in after school to get additional help.

Student 6: Student 6 had his best academic quarter fourth quarter but it was too little, too late. He said he didn't understand he could not pass 7th grade if he failed this class until the counselor explained it to him fourth quarter. He also didn't understand what he needed to do in order to get a passing grade.

Question #3: What could Mrs. Rudd have done (differently) first semester which might have helped you sooner/more?

Student 1: "There's nothing Mrs. Rudd could have done. If I had paid attention sooner, I might have found it more interesting. And I didn't believe they'd retain me."

Student 2: "Mrs. Rudd could have done more activities sooner." Student 2 also thought she needed more explanation of material and more one-on-one time although she didn't want to raise her hand in class or come in other than class time for extra help.

Student 3: "There's nothing you could have done differently because there's nothing you could have done about my attendance." Student 3 also said she first must decide to want to pass.

Student 4: Student 4 said I could have helped students in class with homework. All the homework (that she had to do alone so she didn't do it) brought her grade down. But other than that, Student 4 "needed to help herself."

Student 5: "Nothing would have made a difference. I was interested in being like my friends."

Student 6: "You could have done more activities sooner and given students more time to pick partners for projects." (Student 6's peers never wanted to work with him because of his uncooperative attitude). He added, "If you had done those things, it still wouldn't have made a difference. I wanted to screw around."

PHANTOM OF THE RUBRIC
OR
SCARY STORIES FROM THE CLASSROOM

Presented as a Play

Joan James, Barb Deshler, Cleta Booth, and Jane Wade

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PHANTOM OF THE RUBRIC
OR
SCARY STORIES FROM THE CLASSROOM

PROLOGUE - AN INVITATION

Acknowledging that life often proceeds much like a play or a "Choose Your Own Adventure" story, we invite you to read the acts and scenes of our research "play." This is a dramatic recreation of our struggles and insights. As you read, you will find that the actions of the characters, the unique setting, and the provocative research question lead the play in a maze of different directions that are hard to predict.

To have one's research question change meaning at various steps along the way is probably only normal. Hindsight certainly shows that all our misadventures were necessary to come to the conclusions that now propel us to ask new questions and to be ready for acting out more plays and choosing new adventures in our teaching.

CHARACTERS

The Teachers

Barb Deshler: After obtaining her Master's of Library Science (MLS) degree, Barb was content with her job as reference librarian for the Laramie Public Library for a number of years. She decided, however, to return to college where she achieved two second bachelor's degrees, one in secondary education and the other in elementary education. After teaching a reading methods class at the University of Wyoming and substituting at the Wyoming Center for Teaching and Learning, Laramie (WCTL-L), Barb was hired to teach the multi-aged fourth-and fifth-grade classroom. Previous experience included teaching for the Peace Corps in Kenya for two years. Barb believes that collaboration with students is essential for meaningful learning.

Joan James: Joan obtained her bachelor's degree in special education and her master's degree in curriculum and instruction, completing a master's thesis using qualitative research. As a veteran teacher of 19 years, Joan's experience includes eight years at the kindergarten level and ten years teaching special education for a variety of age levels and a variety of handicaps including mentally impaired, emotionally disturbed, learning disabled, and autistically impaired. This past year she taught a multi-aged fourth-and fifth-grade class at WCTL-L. Changing from a more traditional teacher-centered to a more child-centered approach over the years, Joan willingly tries out new theories and has a flexible, ever-changing teaching philosophy.

Cleta Booth: After her two sons were born, Cleta left teaching English to learn about child development and early childhood education. She completed American Montessori certification and a master's degree in early childhood special education. For nineteen years Cleta has taught normally developing young children and those with special needs in inclusive classrooms. Currently, Cleta teaches the half-day, play-based, pre-kindergarten class. She has recently been influenced by Howard Gardner's ideas concerning multiple intelligences (Gardner, 1983), and by several writers about the use of the project approach in early education (Katz and Chard, 1989, Gardner, 1991, and Edwards, Gandini, & Forman, 1993).

Jane Wade: Jane has taught a total of thirteen years at the pre-kindergarten through college level, including elementary grades, foreign language, and language arts. She has bachelor's degrees in both elementary education and Spanish, with certification in

language arts and French. Jane has developed curriculum for pre-kindergarten through sixth-grade foreign language, and currently teaches foreign language to pre-kindergarten through ninth graders, as well as language arts at the sixth-and seventh-grade level at WCTL-L. Jane values her role as a facilitator of learning as she encourages student ownership of learning activities.

The WCTL-L Kids

The students at the WCTL-L are admitted on a first come, first serve basis without regard to intellectual ability, talent, or socio-economic status. The $275.00 per semester tuition is adjusted on a sliding scale to accommodate lower-income families. Special education students are mainstreamed entirely into the regular classroom.

Pre-kindergarten: A mixed-age class (three- to five-year-olds) of nine boys and seven girls of considerable ethnic diversity.

Fourth-Fifth Grades: Twenty-five students in each of two multi-aged classrooms, with an approximately equal mix of fourth and fifth graders and genders.

Sixth-Seventh Grades: Twenty-three students in each of two multi-aged middle school language arts classes with approximately equal numbers in each grade level, and 3/2 male/female mix. The classes were scheduled for 50 minutes per day, but students often worked in two and a half hour blocks of time during interdisciplinary units.

Narrator

The collective voice of our experience and collaborative reflection.

Supporting Cast

The Parents: Many participate in the governance of the school and most are actively involved in the education of their children both at school and at home.

The Principal: Provides valuable behind-the-scenes support by actively encouraging teacher experimentation and collaboration.

University Students: Student teachers and practicum students team with classroom teachers as part of their teacher-education program.

Supporting Researchers: Audrey Kleinsasser and Elizabeth Horsch led the state-wide research group. Research teams around the state supported, encouraged, and edited one another's work.

THE SETTING

Early September 1994 at WCTL-L, located in the College of Education building on the University of Wyoming campus.

Cleta's preschool classroom is housed in the same area as the fourth-fifth grade classrooms of Barb and Joan. A tall wooden bookshelf partitions Cleta's room from Barb's. Across the hall is Joan's classroom. The sounds of learning dominate the area, as it is impossible to close off the open classrooms. Jane's classroom is located upstairs in a more traditional middle school setting.

The philosophy of the school emphasizes curriculum integration, multi-age interaction, and learning that is meaningful, hands-on, and real-life oriented. The school uses a variety of authentic evaluation tools including student self-evaluation and portfolios. The students do not work from textbooks and are not graded using the traditional A-B-C-D-F format.

As the play opens, Barb and Joan, experienced teachers but new to this school setting, are unsure of the capabilities of the 50 fourth and fifth graders they are assigned to teach. Let the play begin!

ACT I
SCENE I
YUCK, THIS IS BAD! OR NOW WHAT?!?!

(Barb, Joan, and their student teachers decide to have their students engage in a nature study project to supplement the outdoor education camping experience at the end of September.)

JOAN: Hey, I know, let's put out all of our nature books and magazines, and let the kids browse to find a topic that interests them.

BARB: Then we can come up with a list of project ideas for them to choose from, like constructing a poster with captions, writing and illustrating a children's book about their topic, creating a diorama, or scripting and performing a play.

JOAN: I think we should require both written and visual aspects in their projects.

BARB: Since we have four teachers, we could divide the kids into four groups. Each teacher would be in charge of conducting mini-lessons to model what is expected. Let's each come up with some project ideas, type them up, and introduce the project to the kids tomorrow.

NARRATOR: ***Thus the team haphazardly embarked on its first project. They gave the kids an hour a day each day for three weeks to complete their project, and told them they would each do a stand-up presentation of their project at the end of that time. The teachers' mini-lessons consisted of introducing the project and the variety of formats students could use, as well as modeling how to locate useful information, and how to utilize it in their projects without being sanctioned for plagiarism.***

The kids were so excited they wanted to start working right away, making it almost impossible to interest them in the teacher-presented mini-lessons. Most of the kids made quick decisions about what they wanted to do. They wasted little time researching or reading about their topic, and instead, enthusiastically dug into creating the hands-on portion of their project in an attempt to make the visual match up to the ideal they had imagined.

After two or three days of work using paint, construction paper, clay, cardboard, and scissors to construct the visual portion of their project, many of the kids began to lose interest. Their projects lacked planning and weren't turning out as well as they'd imagined. Other students couldn't seem to get motivated to put much effort at all into the project and spent a lot of the project time sitting and staring into space. Others had learned to play the school game. They had quickly (within the first two or three days) produced a grossly inadequate written and visual portion for their project and had happily announced that they were done, expecting to be allowed to have free time for the remaining two plus weeks. When encouraged to revise, edit, and extend their projects, they had absolutely no interest and put most of their energy into passive resistance. As the three weeks wore on, the four teachers spent increasing amounts of time playing prison guard as they policed the easily accessible hall and secluded corners of the classroom for off-task students. There actually were a few, well, maybe a couple, students who really got into their project and worked diligently during each project time in an effort to learn all they could and produce a high-quality product.

JOAN (*to the group of gathered students*): You will have two more days to complete your project. On Friday we will begin the presentations!

Panic and Pandemonium

NARRATOR: ***Those students (a lot of them!) who had wasted the majority of the three weeks, started frantically slopping together their project. Many wrote a rough paragraph about what they had learned to fulfill the written requirement. They were ready!!***

(Friday. A microphone in center stage. Seeing the microphone as they enter, kids panic. Eyes bulge. They gulp. This is for real!)

NARRATOR: *One by one the students made their way to the front of the class and read their reports into the microphone. Modeling after one another, most read as fast as they could, holding their reports in such a way as to hide their faces from their audience of peers. When finished, they quickly held up their visuals and then stood with hands by their sides and heads down awaiting the questions from their peers. Since many had done little or no research, they were unable to answer these questions factually. Feeling pressured to perform well, they simply made up answers. Many of the written reports they turned in were pitiful, containing many punctuation and spelling errors, poor sentence and paragraph structure, and holding little interest for a reader.*

The audience wasn't much better! They felt comfortable talking with neighbors or engaging in unrelated tasks during presentations, and often asked silly questions in an attempt to get a laugh from the crowd.

Following the presentations Barb, Joan, and the student teachers sat down together.

ALL FOUR TEACHERS: Phewwwwwwwwww! (*wiping furrowed brows*).

NARRATOR: *They had a lot of work to do! These initial presentations showed the teachers what little their students knew about quality work and oral presentations. The students seemed initially to be intrinsically motivated but obviously lacked the tools to translate their enthusiasm into quality practice. This created a dilemma for the teachers. "How do we teach and motivate students to delve deeply into a topic, to plan and work diligently toward the production of a high quality project, and present their knowledge to an audience in an interesting and exciting way?" and "How do we communicate expectations for high quality work to parents?" which, in essence, became this pair's research questions (but this is getting ahead of the story).*

SCENE II
WOW, MUCH BETTER!

(After school the next day.)

BARB: You know, I know a little bit about rubrics, and I think they just might be the ticket in helping us communicate to the students and their parents our perceptions of a high-quality project. They might be a good evaluation tool, too.

AMY (*student teacher*): I don't get it. What do you mean by rubric?

BARB: Rubrics are an evaluation tool we could use to briefly, but specifically, describe high-, middle-, and low-quality projects. Then, following a student's presentation, we could evaluate by circling the specific statements that describe their project.

NARRATOR: ***This is the definition of rubric that Barb introduced: "Rubrics provide criteria that describe student performance at various levels of proficiency,"*** (*Making Assessment Meaningful*, August 1994)

JOAN: Well, we obviously have to do something, and this rubric business sounds like it's worth a try.

(Barb's room, the next day after school.)

NARRATOR: ***Barb and Joan and their student teachers met for hours to collaborate in the making of this first rubric.***

JOAN: Let's thoroughly explain this rubric to the kids so they know without question what our expectations are for this next project. As Arter says, "...there are only two choices: we can either make our criteria crystal clear to students or we can make them guess." (Arter, 1993)

BARB: Let's also send a copy of the rubric home in the mail with a letter detailing the project to be sure that the parents get the

information. In the letter we can instruct the kids to explain the project and the rubric thoroughly to their parents.

JOAN: Maybe we ought to have this first project done completely at home with the assistance of the parents so that both the parents and the students will have a rock solid understanding of our expectations.

BARB: That way the parents can take a major role in guiding their children toward quality work.

NARRATOR: *The rubric and a letter of explanation were sent home in the mail with the due date for the project a month away. Once again, the students were required to have both a written and a visual portion to their project. In addition, the teachers encouraged the students to involve the audience actively in their presentations in order to keep the audience's attention.*

Presentations

(Late October. Presentation Day. Stage with microphone. Kids enter looking nervously at microphone, but take their seats quietly. One by one they present their projects.)

NARRATOR: *After about ten presentations, the teachers sent the students off to gym and sat down to discuss what they'd seen.*

JOAN: Wow! I can't believe what I'm seeing!

BARB: These are fantastic!

AMY: Much better than those raunchy nature projects!

NARRATOR: *After school, the team got together to discuss and compare their rubric evaluations. Remarkably, they had usually agreed in their evaluations, circling similar criteria statements and noting similar strengths and weaknesses.*

The written reports were of much higher quality than those seen for the nature projects. It was evident that time and effort had been taken to revise and edit. Most of the children wrote factual reports describing the wealth of knowledge they had obviously acquired through persistent research using relevant resource materials. Many of the reports were written from the viewpoint of a New World explorer or a child who lived in colonial times to make the historical topics come alive for the audience. For visuals the students created costumes, engaged their families or friends as characters in plays they had written, constructed dioramas, drew pictures and maps, made toys, or shared food representative of the colonial era.

The teachers involved the students in a narrative self-evaluation following their presentations. They noticed that most students had a much better understanding of the criteria necessary to produce a high quality project and presentation than they had shown on the nature projects.

While being generally pleased with the presentations and the knowledge the students gained, the teachers found that there were still some areas for student improvement. For instance, they wanted the students to learn their topics well enough to "tell" their presentation rather than read it, speaking in a clear, strong voice, and giving their audience confident eye contact. There were also a few students yet to be motivated.

ACT II
SCENE I
TEACHERS DOING RESEARCH? WHAT A WILD IDEA!

(Late October. Wyoming Interdisciplinary Conference, Casper. A session on collaborative teacher research.)

TEACHER/PRESENTER #1: It's been an exciting journey for me, a classroom teacher, to take a critical look at my own teaching and the learning of my students through a qualitative research project.

TEACHER/PRESENTER #2: Collaborating over compressed video with teachers around the state who, like me, are interested in improving the teaching and learning in our own classrooms has been both encouraging and insightful.

NARRATOR: ***It wasn't long before Barb and Joan were hooked. They wanted to be part of this relatively new model where teachers became their own in-class researchers. Back in Laramie their excitement was contagious and, before they knew it, Cleta and Jane decided to join the team.***

Shortly after Christmas the state-wide research group met in person, and later continued its collaborative work via monthly interactive compressed video discussion sessions. There were a lot of heady decisions to be made at the beginning, number one being, What should our research topic be? Joan and Barb expressed the excitement that the rubrics had produced in their classrooms. Cleta was doubtful but thought it would be interesting to see if rubric criteria would be developmentally appropriate for use with pre-kindergarten children. Jane, seeking a method to help motivate her hormone-driven middle schoolers, was willing to try anything.

SCENE II
CHOOSE YOUR OWN ADVENTURE

Because the three aspects of the rubric research (Cleta at the pre-kindergarten level, Barb and Joan at the fourth- and fifth-grade level, and Jane at the middle school level) are so different, we will now allow you to choose your own adventure and delve into scenes of your choice.

For pre-kindergarten adventures go to Scene II-A (below)

For fourth-fifth adventures go to Scene II-B (p. 55)

For sixth-seventh adventures go to Scene II-C (p. 58)

SCENE II-A
ADVENTURES WITH PRE-K

(January. Barb's classroom after school.)

CLETA: I hate to interrupt, but I've been thinking about my part of the teacher-researcher project. I can't figure out my research question. I don't even know if preschool kids think in terms of good work and less good work.

BARB (*grinning*): Well, you could investigate that. Or try using a rubric, and if it doesn't work, in the worst case scenario, you can report that… and what you learned in the process.

CLETA: I'm already working on including kids more in planning. I'm experimenting with making Know-Wonder-Learn charts when we start a unit and with asking, How can we find out? and What shall we do? Maybe that's all related somehow and could be part of my research.

BARB: That's similar to what we've been trying to do, to give kids more ownership of their learning. But Cleta, one thing bothers me. Would you really tell a four-year old that something she made doesn't meet the standard of a rubric? That feels all wrong to me.

Cleta (*laughing*): Of course not! I might point out, "Sandy, I see your block building keeps falling down and you look upset. Is there something you can change to make the bottom wider?" To me the issue isn't grading... an A, B, or C in block building is a ridiculous idea. I want to give Sandy feedback useful for making other buildings. I wouldn't walk by and say, "Good job. Keep trying," when Sandy knows it's not a good job because it keeps falling down. That's just frustrating. It's not honest, and it isn't helpful. Besides, I'm not thinking about using rubrics to evaluate any one child's work. That could be threatening. For a first step, I'm wondering if the children and I can even evaluate one class project together, decide what makes it good, then try to apply those standards to some other class project. I'm not sure my kids can think that way.

Barb: Well, I feel better about that. How are you going to do it?

Cleta: I guess I'll dig out the tape recorder and then transcribe some of our class discussions when we finish the next project.

Barb: You ought to videotape some, too. And don't forget to tape some of your planning sessions while you are at it.

Cleta: With kids the age I teach, I think it's critical to have the parents involved. I guess I need to find out how they would judge a project. Come to think of it, that's getting ahead of myself. I don't guess I've ever even asked parents what kind of feedback they want about what their child does at school. I've always assumed I knew! I have a feeling my teacher-researcher question is getting out of hand. I'll have to explore kids' and parents' ideas!

Narrator: ***Cleta continued to struggle throughout the research project to make her work appropriate and meaningful for her age group but also to find meaningful connections in it to what the older-grade teachers were researching.***

Ask the Parents

(Spring parent-teacher-child conference in the pre-kindergarten room. The Porter family (a pseudonym and composite of several interviewed) is gathered around a table. They have just finished viewing four-year-old Sandy's portfolio.)

Cleta: Do you have a favorite page in your journal you'd like to share?

Sandy (*opening the journal at random and pointing to a page covered with circular multi-color scribbles*): This one.

Cleta: Why do you like that one best?

Sandy: Because that's the day I got my new pencil that draws all colors.

Cleta: I remember you really liked that pencil. (*Pause*) Could you find the page when we were studying castles, and you made a picture that was lots different? Do you remember? And can you tell your mom and dad about it?

Sandy (*turning to a page with a simple outline on it*): That's the well in the castle. That's where the water is, and there's the bucket, and there's the rope, and it goes up here to the pulley, and here is where you pull to get the water.

Cleta (*to the parents*): Can you see why I think this is so remarkable? The new-pencil picture was typical of Sandy's drawings up to this point. The well picture is a cross-section drawing that shows all the parts and how it works. That's pretty unusual for a four- year-old. And after this picture Sandy began using drawing to represent other ideas. Back here there's a castle, and here's an airplane. (*turning again to Sandy*) Sandy, why do **you** think this drawing of the well is a good drawing?

Sandy (*smiling hesitantly*): Because I liked the well.

NARRATOR: ***That line of reasoning going no further, Cleta allowed Sandy to find activities elsewhere while she and the Porters finished the conference. Ending a few minutes before the next family arrived, Cleta explained her team teacher-research project and asked them to answer two questions to be tape-recorded.***

CLETA: First, what kind of information or feedback about your child do you want from a report or parent conference? What is helpful?

MRS. P: I guess I most want to know how my child gets along with the others. And then I like hearing about interests and activities. I wish I could slip in and watch from a one-way-mirror. I also like to know what you are studying so we can do activities at home to encourage an interest. Your weekly newsletter really helps with that.

MR. P (*interrupting*): For me, it's a matter of does my child fulfill your expectations? I don't have expectations. I assign you the job of having those expectations—and letting me know what they are and how well Sandy is meeting them.

CLETA: Hmm. I'd like to talk about that again when we have more time. Right now I'd like your thoughts on my second question, What kind of evidence do you see at home about your child's learning?

MRS. P: Sandy is pretty quiet—doesn't often tell us directly about what is happening at school, but I always know what the class is studying. New topics like castles or rocket ships just pop into the conversation, and I know it's from what is happening at school.

MR. P: And when we go to the library, Sandy always wants to get a book on whatever topic you are studying at school.

MRS. P: Sometimes I even hear the new interests and new information come up in fantasy play when our neighbor's child comes over to visit. Or Sandy will burst into a snatch of song about a rocket, or draw a picture of planets, or tell a story about a castle. It has happened with almost every topic you've studied.

CLETA: So you both do feel that you can tell that Sandy is learning—and what Sandy is learning?

BOTH PARENTS: Oh, definitely.

MR. P (*rising to leave*): But we do need to know if Sandy is meeting your expectations.

NARRATOR: ***From learning about Joan and Barb's experience, Cleta realized that rubrics might do exactly what Mr. Porter asked. But did rubrics make sense for looking at the work of young children? She had serious doubts. It was time to talk with the children.***

Ask the Kids—1

(Early May. 15 three- through five-year-olds are gathered on the rug for a discussion with the teacher.)

CLETA: It's getting near the end of the year. I wonder what projects we've done this year that you think are really good projects? What did you like best that we've done? And can you tell me why you think that one's a good project?

NATHAN (*age 5*): Rockets! We could go in it. And I like rockets.

AURORA (*age 5*): Castles was best. We got to go in it, 'cause I like castles.

NORA (*age 5*): Castles. I really like being the princess... no, the prince.

TOD (*age 5*): Airplanes. I got to be the pilot.

CODY (*age 5*): I liked bananas best. Bananas are good to eat, and I liked to pretend going to the beach. And I liked the real sand.

EVAN (*age 4*): And the boats had water and fish.

Darla (*age 3*): I liked to color. Housekeeping.

Rosie (*age 5*): Studying about Chinese things was best because I like to pretend writing Chinese and make Chinese paintings.

Narrator: ***The discussion continued, dominated by the older children, until almost every project had been named. Many children named several that they liked best. Cleta transcribed the tapes and looked for patterns in their responses. Meanwhile...***

Ask the Kids—2

(Same as above, two days later.)

Cleta: When we talked about your favorite projects, I was surprised no one mentioned the chocolate friendship cake. Maybe it was too long ago.

Evan (*age 4*): It was gooodyyy!

Ned (*age 5*): I got to take some home.

Cleta: What made it a good project?

All (*in chorus*): I brought... (*listing the ingredients.*)

Cleta: You all contributed ingredients that made it taste good. Do you mean that one thing that made it a good project is that everybody contributed? (*many nods*)

Narrator: ***Clearly each child had meant that his or her ingredient made the cake taste good. Cleta realized she was trying to lead them to a more abstract definition of a good project (her definition!). She reminded the class that they had had to make many decisions on the cake project, and the children agreed and were able to recall them. They also recalled sharing it with the other classes and their families. With the children's agreement, Cleta formulated criteria for a good project: everyone contributes, it involves shared decision-making, and the final results are shared with others. She then asked them to apply the same criteria to evaluate another project.***

Cleta: Let's see if we can use those ideas to see if the castle project was good for the same reasons. Did everyone help make it or do it?

All: Yes, painted it—marked lines on it.

Narrator: ***With the teacher scaffolding, they could apply the set of criteria. They easily recalled decisions they had made as a group to set rules for the castle and that they had shared by giving everyone the secret password for the drawbridge, including the older children who came for weekly integration activities. Cleta realized, however, that they could not apply criteria without a great deal of adult help.***

One More Dialogue

(The house of Rosie, a very verbal, unusually reflective five-year-old, and her mother, Anne, who had volunteered in the classroom weekly.)

Cleta: Rosie, we've put all the books you made here on the table. Do you look at them and think, "This is my best book?" or "This book is good because of the pictures, and this other book is good because of the story, but this other book isn't as good because I was in a hurry?" or anything like that?

Rosie (*emphatically*): I don't think it's that way, because I've already made lots of books before I start.

Cleta: So they are all good books in their own way? (*Rosie nods*). Well then, would you choose one you especially like?

(Rosie reaches for one with her name and the number 5 on the cover. It was made soon after her fifth birthday and laminated for our class to keep and to remember her when she was in kindergarten.)

Cleta: Why did you pick this one?

Rosie: The rocket one. It's fun, and you can read it on your bed.

Narrator: *Cleta probed, and Rosie offered many reasons, including "It get's done soon," "It looks like a real rocket," and "It's for you," but Cleta could recognize no coherent pattern to her responses. Cleta decided to check Rosie's previous response about projects.*

Cleta: Rosie, tell me about which was your favorite project, or the one you thought was the best project the class did this year.

Rosie: Space! I liked pretending to land on the moon.

Cleta: Any other reasons you think space was the best project?

Rosie: You could go inside the rocket.

Narrator: *This response was interesting, because in class Rosie had picked a different project. Her answer today was at least in part because she had just been talking about her book on rockets. It also confirmed conclusions Cleta had begun to draw about what children value in projects. Rosie left to play, and parent and teacher continued the conversation.*

Cleta: Anne, you were in the class every week all year and probably have a better view of what went on than anyone. Which project do you think was the best? What do you think makes a good project for this age group?

Anne: I think the best projects were ones that had a real personal connection and effect—like tying in what they were studying with your trip to China. They really felt connected to you while you were away. And of course castles, because children this age are all caught up in fairy tales. Space wasn't personal to them, but like dinosaurs, it's one of those topics that always seem to catch their interest. I'd say projects that involve making something or building something—something concrete—are best. Also projects that help them understand how something happens.

Cleta: Anything else?

Anne: Parents will have a different set of issues and values from kids. Personally, I think the most important criterion for a good project is that it generates a spark of interest that continues at home—and maybe creates an interest that lasts into the future—a sense of possibilities for learning and excitement. Rosie still talks about wanting to be an astronaut.

Cleta: I've explained what rubrics are. Do you think some version of a rubric for our projects would be helpful to parents?

Anne: What would be helpful is to know the individual child's contribution to a project. And a way to alert the parents to things to listen for in the children's play and fantasy and storytelling so they can build on the ideas at home that they are learning at school. I'm not interested in any kind of rating or judging of the children's work.

Touching Base

(Barb's room after school. Joan and Barb are talking. Cleta joins them.)

Cleta: I'm beginning to pull together my data from all the different sources for the teacher-researcher project. I guess what I've really been doing is comparing what teachers (at least this teacher), students, and parents value in a project—defining our implied rubrics.

Barb: And...?

Cleta: My own criteria for a good group project focused on the process of it: that it requires joint problem-solving, that it encourages cooperation and joint participation (everyone helps), and that it involves sharing with an audience or bringing in another group of participants. The kids could understand and make judgments about those characteristics, but they were clearly my criteria, not theirs.

Parents looked more at the effects: that it involves the children personally, shows them concretely how something is done or made, and most importantly, that it sparks an interest that encourages the child to keep learning about the subject outside of school.

The kids, of course, had their own priorities: a good project must have opportunities for fantasy and role-playing. It's even better if it creates a physical environment you can actually go into for that role-playing. And it's good if it offers opportunities for creative art work and construction. For projects that aren't the role-playing kind, the most important criterion is that it tastes good!

JOAN (*laughing*): That's my kind!

CLETA: I've also learned more about how kids think from this research. The three-year-olds had almost nothing to say. One girl said she liked housekeeping and coloring pictures best. That's really the same criteria of fantasy play for a go-into environment with the opportunity for creative art work, but for her the larger content framework of the particular project wasn't important. The fours and fives did have interests in particular topics, like space or castles. The fives tended to talk more, to be eager to tell their favorite project and the reasons. I think they have a clearer idea of "reasons."

BARB: Didn't you tell me you were reading something that said three-year-olds thought in a completely different way?

CLETA: Yes, Janet Astington was reviewing research that shows that children begin to be able to think and talk about their own knowing at about age four. They can talk about wanting even earlier. Maybe that's why the threes didn't have much to say.

But Astington (1993) does say that children who have lots of experience hearing talk about knowing and about reasons reach the stage of being able to talk about knowing and reasons sooner. Even if I'm asking something of the group that three-year-olds can't do, maybe it models a kind of thinking that is useful for them to hear. It's still a stretch for many of the four-year-olds, but more comfortable for the fives.

I did notice that when I asked even the fours and fives to pick out their best drawing from their portfolios or identify their best work, they usually seemed to pick at random. I don't think "best" is very meaningful to them.

JOAN: So, did you decide that rubrics weren't appropriate for preschoolers?

CLETA: I don't think rubrics, as you use them in the upper grades, make any sense for preschoolers. But I'm convinced that the communication of clear expectations to children and parents is important at all ages. In setting those expectations, I just want to be sure to take into account the parents' and children's values too.

NARRATOR: ***Cleta went on to tell about her concern that most American early-childhood teachers have low expectations about what young children can do. She described the art work she had seen when she visited China, and how it was two to four years ahead of what children in her class do. She also told about similar work she'd read about from preschools in Reggio Emilia, Italy (Edwards et al., 1994).***

JOAN: They don't use rubrics in China or Italy, do they?

CLETA: No, but they do hold up good work and talk about why it's good.

BARB: But doesn't everyone just copy it?

CLETA: Sure, some do, or they try to use the particular technique that was pointed out, but isn't that a useful way to learn—to be shown the characteristics of a good model? Didn't you discover that children model from each other anyway?

JOAN: They certainly do. And we found from our experience that we needed to raise our expectations and give children better feedback.

CLETA: In Reggio Emilia they use a novel approach to feedback that they call documentation. They constantly photograph and video and tape record the children as they work. Then they make beautiful displays of all of the stages of a project as it unfolds. Children are encouraged to keep going back and adding to their work, reflecting on it, trying it in a new medium. Feedback is continuous and comes from the teachers, the environment, and even the other children. They don't use the specific criteria of rubrics, but they provide the feedback for children to meet the expectations for high quality work. Early childhood teachers here should probably be doing that too.

NARRATOR: *Cleta was still uncertain about the best way to give children and families feedback, but she was very pleased that her findings connected with those of the older-grade teachers. This collaborative research project had made her feel a more integral part of the school than anything else in her seven years there.*

For the fourth-fifth adventure go to Scene II-B (below)

For the sixth-seventh adventure go to Scene II-C (p. 58)

For the conclusion go to The Rest of the Story (p. 59)

SCENE II-B
JOANIE AND BARB'S RUBRIC RUCKUS

(Early Spring semester. Joan's room after school.)

JOAN: Basically, for our research question, we've decided to explore this rubric phenomenon further to see if it continues to be a successful tool for helping our students achieve high quality work. How can we take a further step with the rubric so we continue encouraging high-quality work?

BARB: I'm not quite sure yet. Let's both think about it.

NARRATOR: *The rubric had helped Joan and Barb communicate their expectations, and most of the students had shown that they knew how to use the criteria in the rubric to produce high-quality work. Parent enthusiasm for the previous project had been high. Many of them had come in to watch their own child's presentation and then had stayed to watch others. Joan and Barb thought it was a good idea to display all the students' work, so the hall turned into a Colonial Museum. More parents, other students, and teachers in their school came to look at the projects and comments like these were overheard: "I am just amazed by what these kids did. I have my college students do similar projects!," "I wish we could do these kinds of projects at my school" (a visiting student), and from the younger and older kids in their school, "cool," and "awesome."*

Some parents made it a point to say how much they had appreciated the letter and the rubric that had been sent home. "It helped me understand exactly what my child needed to do for a good project. It gave us excellent guidance," said more than one parent. It was, however, time to move on.

(A few days later in the hall between Joan's and Barb's rooms.)

JOAN: I think I've got it! For the next rubric adventure let's give the students the opportunity to explore something they are interested in. This could be their chance to explore something they're curious about, or even to share something they already know a lot about.

BARB: That sounds like a great idea. They would have the freedom to choose a topic meaningful to them personally. How do you see using a rubric with this idea?

JOAN: The rubric for this exploration project would be a way for us to provide guidance for quality work. Even though the kids will be able to choose their own topics, they should still do their best work in terms of process, product, and presentation.

BARB: I agree, but is there a way we can try something a bit different with the rubric this time? I remember hearing a teacher talk about

rubrics she used with her students, and how she eventually got the kids to help her write the criteria. She felt if they helped write the criteria, they would feel more ownership, and, therefore, take more responsibility for their own work.

JOAN (*always game for anything*): Good idea!

NARRATOR: *Joan and Barb decided to give the students the opportunity to come up with rubric criteria. Handing out blank rubric sheets with only the basic headings, they asked the kids each to fill in the criteria and then discuss their ideas in small groups to come to consensus. Following this, each small group's ideas were written on the board in an effort to arrive at agreement on each criteria. This was a rather time-consuming and tedious process but extremely important in giving the students a feeling of ownership.*

Joan and Barb, surprised at the similarity of both classes' rubrics, observed that the students seemed to internalize the criteria from their previous experience. That evening Joan and Barb combined the criteria statements of the two classes in order to produce a final rubric that would serve as a guide for everyone.

During much of the Spring semester, the exploration project time was utilized fairly well by most of the students. For some kids this was their favorite part of the day, and Joan and Barb were awestruck by the high quality and professionalism of many of the performances. Some students took such command of their topics that they took full control of the class for about a half hour while they did their presentation. One group of three girls delved deeply into an exploration of the Holocaust. They read many books and had diligent discussions about the unbelievable occurrences of that time in history. They decided, with the help of an older sister, to write and perform a play.

Other kids dug just as deeply into their areas of interest. One boy did a presentation on Medieval times, and another involved his family in helping him make a videotape about ice climbing in which he was the main actor. A boy, who was an incredible artist but who had a hard time doing "school things," did a presentation on Michelangelo and Leonardo da Vinci and showed drawings he had done using their works as models. A girl did a presentation about Pearl Harbor that was so professional that she presented it two more times for other classes in the school.

Barb's Classroom

Barb's classroom during exploration project time. One of several students is having a hard time finding a meaningful topic he can stick with.

BARB: Tell me some things you're interested in.

STUDENT (*with frustration*): I don't know.

BARB: Well, tell me what you do when you go home from school.

STUDENT: I ice-skate.

BARB (*with interest*): Why do you ice-skate?

STUDENT (*smiling*): I play hockey.

NARRATOR: *And there it was, a driving interest. This student consequently brought in a huge bag containing all of his hockey gear to show to the class for his presentation. The students (and Barb) were mesmerized. This rather shy student showed us all his gear, used the blackboard to draw a very clear hockey field, showed us what each player was supposed to do, and answered all our questions about hockey.*

Not all students were so successful, and some went back to their old habits of avoidance. Joan and Barb realized that rubrics weren't working to motivate everyone, so they had the kids keep track of what they got accomplished each day by filling out a calendar. This helped some kids see that they weren't meeting expectations. Some improved; others didn't.

Joan soon came up with a brilliant plan. She asked the kids to look at the rubric they had helped create and to use the criteria to evaluate their peers after each presentation. She modeled this procedure by evaluating one of the presentations aloud while consulting the rubric in her hand.

JOAN: Jimmy, I noticed that you accurately answered our questions. How do you think you could have more actively involved the audience?

NARRATOR: *Joan also asked the presenters how they felt about the behavior of their audience. Then Joan asked the audience to give the presenter positive feedback followed by suggestions for improvement. The kids gave excellent feedback to each other using this praise/suggestion format, and they often used phrases from the rubric criteria to clarify their suggestions.*

Each child was also required to complete a self-evaluation using the same rubric criteria. Joan and Barb felt that this evaluative side of the rubric was a powerful incentive for students to try to do high quality work. The more the rubric criteria were used to evaluate, the more the kids seemed to rise to the challenge of meeting or going beyond expectations. The students knew they would evaluate themselves as well as be evaluated by their teacher and their peers, and they knew exactly what the standards for a high-quality project entailed!

Joan and Barb, for the most part, were quite pleased with their students' responses to the rubric the students had helped to create. There are, however, always the unexpected responses, and things weren't perfect. Some of the students never bought into the opportunity to do their own exploration. The exploration projects had, for the vast majority of the students, given an opportunity to further explore their own interests and to share them with their peers. Classes were enriched by student presentations on topics they wouldn't have ordinarily had the opportunity to learn about. In addition, the students became more capable of evaluating themselves, their audience, and their peers. The rubric had helped the teachers communicate criteria for quality work. Joan and Barb were aware that this was a process, and that processes are often messy. They were learning and so were the kids. Other rubrics were used throughout the semester for a variety of activities and projects in all subject areas.

The Finale ... By Golly!

NARRATOR: *As a final attempt to understand the role rubrics had played in their classroom, Joan and Barb decided to send a questionnaire home to the parents. They got only a handful back, but they learned that the rubrics had helped the parents understand the expectations for projects more clearly. Some of the parent comments were:*

- [The rubric] provided a foundation on where to begin and where we're going.
- I appreciate having the standards in writing because they are clear and available for reference.
- [Our child] appears to understand what is expected from her and strives to meet, if not exceed, the standards set.
- [Rubrics] helped us to know what was expected, making it quite clear. [Rubrics] allow for a lot of creative space.
- We have a much clearer understanding of what you expect.

NARRATOR: *Joan and Barb decided that one more step was necessary. Wondering what the students thought about the rubrics, they decided to ask. This is what the kids said:*

- Rubrics are fun...
- Rubrics are great! They clearly show what the expectations are. They also helped me a lot with keeping organized.
- Rubrics are like a guideline.
- The reason I liked the rubrics [was] because you know what you are supposed to do, and you know how well you did.

- I like how [the rubrics] got me to work harder on projects.
- I liked them because I could see how you thought about the project that I did.
- I do think it helped me evaluate myself and others.
- I think that to make the rubrics better, the teachers could have let us put in more. They let us make one once, but I think that that one was the best because that way, we could say what we thought and it wasn't like a grade, more like comments.
- Rubrics are helpful because then you know what the teachers expect from you.
- I liked it because it showed me what to work on and what not to work on.
- I liked the rubrics because they helped me learn what was expected of me so I would not just rush.
- I really enjoy the rubric because people that use them get really good feedback on whatever they did, either a project or something else they did. It has helped me because I get input on things that I have maybe skipped or overlooked when I have done my project.
- Rubrics helped me so I didn't slop together my projects.
- … rubrics gave me a goal so I worked harder.

NARRATOR: ***Not all the students' comments were favorable. One child, who incidentally hated to write, "hired" a friend to help him say, "I don't like it. I don't like it because you don't have to put it all down on paper, you can just say it. It doesn't help me. It is a waste of paper and you just forget about it."***

Another student said, "A lot of the time the rubrics didn't do much for me except make me feel bad about certain areas… I don't think you should put sentences on there like I had 'poor spelling, punctuation, grammar, etc.,' and you should put things like that more gently."

Someone else said, "The rubrics didn't help me at all." It's interesting, however, that we got the opposite view from this child's mother!

One student said, "With rubrics it's easy to compare with peers and say, 'Mine is better than yours, etc.' Also too many rubrics at once are overwhelming."

Joanie and Barb realized that they had only begun their adventure with rubrics. They discovered that the more they knew, the less they knew, but the journey had begun…

For pre-kindergarten adventure go to Scene II-A (p. 49)

For sixth-seventh adventure go to Scene II-C (below)

For conclusion go to The Rest of the Story (p. 59)

SCENE II-C
UNSOLVED MYSTERIES IN THE MIDDLE SCHOOL

(Mid-April. After school in Barb's classroom for a brief meeting of teacher-researchers.)

JANE (*plopping herself down on the couch in Barb's reading area*): I am so frustrated. I don't think I'll ever get this rubric off the ground. I feel like giving up and going back to just giving the students my objectives for this project. It would be a lot easier.

BARB: What's the matter?

JANE: I can't believe this happened. I was feeling so prepared because of all the work I've seen you and Joanie do with rubrics and all the discussions we've had about how to develop rubrics with the students. I was all psyched to have the students create their own rubric for the Planet Fair. We discussed rubrics, I showed them sample rubrics from various grade levels, and then we began brainstorming categories which students felt were important in the evaluation process. They came up with this great list of ideas, and we were already beginning to develop criteria for evaluation.

Joan: That was one of the best parts for us, too. The class does know what needs to go into a quality project.

Jane: Yeah, they sure do. In fact, I brought the brainstorm list to the sixth-seventh grade team teachers' meeting to show them what we had begun to do. One of the teachers was so impressed with the list that he asked to take it and type it up on the computer to get it organized. I said, "Sure, thanks," and the team continued on with other business.

Cleta (*nodding*): Great. It sounds like the rest of your team is interested in using the rubric too.

Jane: Oh boy, the interest was so high that the teacher took the categories, added criteria from another source, copied it off and handed it out to the students during his morning class! The students came into language arts this afternoon telling me they already had a rubric for the Planet Fair and produced the copy to prove it when I protested that we hadn't completed a rubric yet.

Joan: What? All this was done without the rest of the sixth-seventh team's input?

Jane: That's right, and there goes the student-made rubric for this unit. I just assumed everyone on the team was fine with student-created rubrics, but I assumed wrong. What a bummer. When I asked why the teacher had decided to make the rubric, I was told that, in his opinion, the students were not capable of formulating valid criteria for assessment.

Narrator: ***At this point, Audrey, one of the co-facilitators of the teacher/researcher project, stopped by our meeting and sensed the umbrella of gloom hanging over Jane's head. After hearing a brief explanation, Audrey offered her perspective.***

Audrey: This incident is an important component of our research. We need to continue to address the issue of collaboration and communication with all people involved in or affected by our research question. Just include this incident as part of your research and go on. This is valuable stuff.

Narrator: ***Wow! A professor who values failure as part of the learning experience? Outstanding. Jane took Audrey's advice; she went on to explain more fully to the sixth-seventh grade team the research question and figured out how to incorporate a student-made rubric into the next unit.***

The Rest of the Story

(Early May. Sixth-seventh grade language arts class. Samples of rubrics from various grade levels and subject areas are laid out on each table as students enter the room.)

Narrator: ***The sixth-seventh grade team used the student/teacher-made rubric to plan and assess the Planet Fair projects. Students, parents, and teachers were pleased with the outcome, but the rubric often didn't reflect everything the students had accomplished, or it was repetitive, or too wordy for the students to understand. In other words, this experience became a building block for the development of a completely student-driven rubric. The opportunity came with the next integrated unit, The Ocean. In Jane's language arts class, students had been reading the novel, The Pearl, and were gearing up to write an analysis of one of the characters in Steinbeck's novel.***

Alice: What are these for, Mrs. Wade? I thought we already did rubrics this year.

Jane: Let's take a look at these samples one more time. Your cooperative group is in charge of making your own rubric which describes the criteria for evaluating this essay on character analysis. You may use your own ideas or borrow ideas from the samples. After each cooperative group develops its own rubric, we will try to come up with a consensus about what this essay needs to look like.

EVAN: You mean we get to decide what our paper should have in it… totally?

JANE: You sure do, Evan. Now, here's the deal, each of you needs to follow the assignment: an analysis of one of the dynamic characters in the novel. But we are working together to create a plan for evaluating the quality of your essay in the categories we decide are important to assess. Other questions?

MICHELLE: Do we have to use these categories in the samples? What if we want more than just "Exceeds Standard," "Meets Standard," and "Does Not Meet Standard" for our scale?

JANE: This is our rubric, come up with a plan in your group, and we'll discuss it together.

NARRATOR: *What was obvious as the groups began working was that these middle schoolers knew what a quality essay needed to look like. In fact, they often insisted on tougher criteria than Mrs. Wade would have, particularly in the area of mechanics. Some strong opinions surfaced about the definition of quality work, as evidenced in the interchange below:*

STUDENT #1: Why does this rubric say you can only exceed the standard with zero spelling errors? Do you have to be perfect to write a high quality paper?

STUDENT #2: Hey, just use the spell checker.

STUDENT #3: That doesn't always work. I used the spell checker and still had tons of errors on my young authors' story when Mrs. Wade edited.

STUDENT #4: Well, you need more than one editor before your final draft.

STUDENT #5: What about if you have trouble with spelling, if it's hard for you?

STUDENT #6: Yeah, and what about grammar? That's the hard part for me. I can spell, but I hate all the grammar rules.

NARRATOR: *During this interchange, Mrs. Wade stayed in the role of facilitator, encouraging students to come to their own conclusions about what was important in the evaluation of the essay. As the class continued to discuss various categories, they came to consensus on some items and had to resort to majority vote on others. Mrs. Wade noticed how confident each student became in this process. Even students who were not usually strong discussion participants had their group's rubric in front of them so that they could refer to it and emphasize important points for the entire class. Some students were initially confused by the teacher's refusal to just step in and make a decision, but they soon realized everyone was making the rubric together. Students used their power very responsibly; no one tried to get away with poor quality criteria.*

The rubric development process took three class periods, which included time to assess each other's rubrics and come to a consensus on a class rubric. The rubric aided in the editing and revision process because its criteria became a guide for student decisions about the amount of effort they wanted to put into the assignment. They were not writing to please the teacher but were choosing to meet a specific criteria in content and mechanics.

The sixth-seventh grade team will use this rubric-making process as a springboard next year because it is such an open-ended, ongoing tool for authentic assessment. What is certain is that the rubric will change, it will grow, it will become more valuable as a learning tool. What is still unknown is exactly what the rubric will look like because this form of feedback evolves along with the students, teachers, and parents as all of us continue to work for positive change in the classroom.

ACT III
PUTTING IT ALL TOGETHER

(A warm July day. The four researchers, clad in shorts and sandals, gather in Barb's classroom.)

JANE: Okay, our bodies and brains have had some much-needed relaxation. We ought to be able to put this puzzle together now. Let's go around the table and summarize our conclusions.

CLETA: I've decided that the whole issue, at least for my age group, is not so much about using rubrics as about having clear expectations, high standards, and giving specific feedback.

BARB: I agree! Before we created and introduced these rubrics to our students, we hadn't been describing clear parameters of a quality project to our students. Many of the things our students are now doing well with the help of a rubric, they never had thought of before.

JANE: The rubrics have been consciousness-raising for the kids. Through the use of the rubrics the kids knew exactly what was high quality and what was poor quality. They had to decide how they wanted to perform. The specific feedback provided by the rubric has proven to be very helpful in improving most students' performance. I think it is a much clearer assessment tool than traditional grades.

JOAN: As we educated the parents in the use of rubrics, we found that the parents began to examine them with their children and talk together about expectations. The rubrics allowed the kids to set their own goals, putting the responsibility for learning more on the students' shoulders.

NARRATOR: ***Thus, through this sharing dialogue, the team arrived at their first conclusion: Rubrics served as a tool to elevate quality by making expectations clear concerning a student's work. All agreed with the importance of having specific standards, high expectations, and systematic feedback for students.***

BARB: Involving the students in creating the rubric and requiring them to use it for both self-assessment and peer-assessment completes the cycle.

CLETA: What do you mean?

BARB: We used to do the planning and the evaluating. Then we began to include students in the planning. This project has extended that. Now the students are involved in assessment… and in planning the criteria for assessment. Having their opinion of what should be the parameters of a high-quality project taken seriously has given most students power and ownership, and an increased enthusiasm for learning.

CLETA: Yes! I see! It makes assessment an episode of learning, not something separate.

JOAN: The students felt a lot of power when giving feedback to others in the class, and they didn't abuse this power. Most students giving the presentations were much more prepared because they knew they would get honest specific feedback from their audience of peers as well as from the teacher, student teachers, and practicum students.

JANE: When students are required to evaluate themselves, as well as their peers, it puts everyone on a more equal footing, and makes the work itself more important. Teachers as evaluators are no longer put on a pedestal.

NARRATOR: ***Once again, the team had arrived at a very valuable conclusion: Involving the children in the creation of rubrics completed a cycle. Students were now involved in both assessment and in planning the criteria for assessment. Having their input valued gave most students increased ownership and enthusiasm for learning.***

JANE: I've been thinking about the Grant Wiggins (1993) chapter we read. He says that American teachers tend to avoid telling students how they are performing in relation to a standard. We don't want to damage anyone's self-esteem. We tend to lower our expectations for students and accept their first efforts, which are often much less than their best. Our experience with rubrics has helped us raise our own standards.

CLETA: That's an interesting point. We do need to be positive and encouraging, but the "pat on the back, good job" trend encourages mediocrity.

JOAN: Yes, I think so. Setting high expectations and providing the students with honest feedback has resulted in much higher quality work.

NARRATOR: ***The team had arrived at their third conclusion: Rubrics are one tool for refocusing students, parents, and teachers on a truer understanding of what is useful feedback. Rubrics remind teachers not only to be encouraging, but also to insist on high standards and provide specific feedback about ways students can improve. Rubrics create an increased awareness of the continuous cycle of goal-setting, working, feedback, revision, and further goal-setting that sustains learning.***

CLETA: The main finding from my research is that children, parents, and teachers all value different things about a project. Young children prefer to learn through fantasy, role play, construction, and artistic creation.

BARB: From informal interviews with students about the rubrics, I've also found that kids often value different things than adults. For example, my students think that presentations that are interesting, but short and to the point, are of high quality, as are projects actively involving the audience with things to touch, taste, or fantasize. Our teacherly way of seeing things isn't necessarily the way kids see things.

JANE: Interestingly enough, the middle school students value the same types of learning experiences, and they rate student projects of that type higher on the rubric.

NARRATOR: ***The fourth conclusion was obvious: Paying attention to what children value is important across grade levels.***

JOAN: Rubrics can allow for a lot of different approaches to learning. I've worked a long time with children who have special needs, and I've found that rubrics worked well for those kids in our class here.

JANE: Rubrics can set high standards and still allow many ways for kids to do high-quality work. That's necessary if rubrics are to be useful and fair. I don't want rubrics to be interpreted as requiring every student to do exactly the same thing.

JOAN: There are choices that kids can make to use their strengths. High standards, with specific parameters, as well as a lot of choice in how to reach those standards is important.

BARB: A fourth-fifth grade math experience illustrates those points well. We didn't exactly do rubrics, but we set a standard that each child would show 100% mastery of the multiplication tables by working problem-sets perfectly within a comfortable yet specified time limit. They could keep working on this task until they had mastered it. I had one child in particular who was overwhelmed by having to write down the answers to a whole page of multiplication facts on a timed test. Sensing his frustration, I allowed him to complete the page one line at a time, orally. When his total time was added up, he was one of the fastest in the class.

JOAN: I had another student who had a severe case of test anxiety. When I took the stopwatch away and told her not to worry about the time, she completed the task in much less than the specified two minutes. She was unaware that I had glanced at the second hand on the wall clock just to check.

JANE: Yes, having different ways to meet the standards is vital for all kids, not just those with special needs. Allowing diversity in the ways students arrive at objectives allows students to demonstrate knowledge using many different strengths or intelligences.

NARRATOR: ***The team had, through their discussions, come up with another important conclusion: To be useful and fair, rubrics have to set specific standards, but allow room for variations in the ways students meet those standards.***

CLETA: I'd like to change the subject a bit. Even though we were all doing different things, and mine was the most different, I found it really helpful to have the three of you, individually and as a group, to talk things over with. You really helped me figure out what I was doing. I think that is my most important conclusion from all this research.

JANE: Mine too. It didn't matter that our projects weren't the same. We could still get helpful feedback from each other.

JOAN: I really want to keep up our discussion. Wouldn't it be great if we could get more of the faculty to participate?

BARB: This project has encouraged me to read more, and it's been helpful to get everyone's perspective on what I'm reading. I'd like to start a faculty book-discussion group to meet regularly. We're starting to use Howard Gardner's idea of seven intelligences as a framework for assessment and reporting throughout the school. We need to all be reading and talking about this aspect of our school philosophy.

JANE: Yes! And each one of us has special areas of knowledge. Just think what we'd learn if each person took a turn suggesting something we should all read, then leading the discussion on that subject. It wouldn't even have to be long books; an article or excerpt would do to get us started. The shared thinking and talking is what's important!

CLETA: I'd also like to see us continue some shared research projects. I've learned so much from the team's encouragement to experiment and expand my thinking.

BARB: Okay, we've all agreed. We'll find some way to continue discussion and collaboration, maybe by reading and discussing ideas as we try them in our classroom. And... we'll open this regular collaborative group up to other faculty who want to join. In fact, we'll encourage them to participate.

NARRATOR: ***The teacher-research team had just reached what they considered their most important conclusion: It is essential for teachers to meet regularly and talk together about common efforts to make positive changes in their classrooms. Teachers learn a great deal from each other.***

EPILOGUE
LOOKING AHEAD TO THE SEQUEL: SCARY STORIES FROM THE CLASSROOM, PART II

CLETA: Do you think there's any danger that rubrics could turn into the old letter-grade system in disguise?

JOAN: Good point! Maybe rubrics shouldn't have a below, meets, or exceeds expectations component that is so similar to letter grades.

JANE: With rubrics designed that way, some students are still content to do the least they can to get by. They don't care if the assessments tell them they did work that was "below expectations." I'm not sure what to do to motivate these students.

BARB: Maybe the rubric should only give very clear descriptions of different aspects of excellent work, and we should insist that every student meet these expectations.

JOAN: And if the expectations weren't met, the student would be required to revise, edit, or redo until a high quality product was achieved. In this way both the process and the product are of equal

importance, and it would be much more likely that all students would be motivated to produce high-quality work.

CLETA: What about the issue of parents, kids, and teachers having their own agendas for what makes a good project? How do we take parents' views into account? And how can the use of more imagination and arts at all age levels help children learn?

NARRATOR: ***This team of teachers has clearly only scratched the surface of classroom research. It seems that the more they discover about themselves, their students, and their classrooms, the more obvious it becomes that they have much more to learn through their collaboration.***

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TIME IS A *BIG* THING: A MULTI-AGE STUDY OF STUDENT TIME SCHEMAS

Anne Marken and Andrea Varcalli

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TIME IS A BIG THING: A MULTI-AGE STUDY OF STUDENT TIME SCHEMAS

The teacher-researchers surveyed a multi-aged group of students about their concept of time. The initial findings of student time schemas revealed an understanding of measurement units, the purpose of a schedule, and simple abstractions based on clichés. Students then participated in classroom exploration activities, including a multi-age collaboration session, to broaden their understanding of time from a past, present, and future frame of reference. These activities were curriculum based using geologic time of the past for ninth-grade study and time measurement in the present for fifth-grade study. As a result, students of both age groups displayed a broader understanding of time and could articulate the relatedness of the past, present, and future. Students internalized the importance of time. By learning about the past, students correlated concepts of biodiversity, evolution, and extinction. Students of both age groups demonstrated abstract thought that challenged teacher conceptions about developmental thinking.

INTRODUCTION

Student ability to manage time is central to success in any curriculum area. The process of experimentation requires students to apply time as a variable and monitor changes over time. Students need a concept of time before they can understand earth science topics such as geologic time or light years. Our curricula assume students have a time schema as part of their background knowledge. However, this schema is typically shallow and includes information only on how to tell time from clocks. Semb and Ellis (1994) note that students having background information on a given topic retain the new information they are learning better than students without background information. We then asked the question, Can we provide students with experiences that broaden their understanding of time so they are better able to interpret time in the past, present, and future?

For the purpose of this discussion our definition of schema is simply a mental map of student thought. A schema is an outline, diagram, plan, or preliminary draft (Neufelt & Guralnik, 1991) that learners mentally refer to when acquiring new knowledge. Piaget refers to a schema as the logical mental structure developed through physical exploration and guided questioning (Copeland, 1988). Thus, the experiences needed to broaden schemas must involve manipulatives as well as engaging questions for thought and discussion.

RESEARCH SITE

Students of Dean Morgan Junior High School (population 930) and students of Crest Hill Elementary School (population 490) were involved in the study. The ninth-grade students (n=44) were part of a regular-level earth science course and the fifth-grade students (n=26) were the homeroom section of a three-section fifth grade. Research was conducted in the regular classroom setting for these students except for the joint wrap-up session that was held in the Dean Morgan gymnasium to accommodate the numbers of the collective group. Students in this study come from diverse socio-economic backgrounds that can be generalized as middle to upper-middle class: two percent of Crest Hill and 32 percent of Dean Morgan students receive free or reduced lunches. The elementary school is a feeder school to the junior high school along with five other elementary schools. However, based on the school-lunch data Crest Hill draws from students of a higher socio-economic level than the junior high school. We feel that the school-lunch data also gives an indication that Crest Hill students have opportunities for extra-curricular activities affording them a broad base of experiences not typically available to all students in this age group.

The research team originally involved three teacher-researchers, but due to time demands, one teacher opted out of the study. The remaining team was composed of two teachers, one a junior high teacher and the other an elementary teacher. Andrea Varcalli is a combination eighth-and ninth-grade science teacher with eight years teaching experience. The target group she used with this study was the ninth-grade earth science students in her afternoon classes. Anne Marken is a veteran elementary teacher with ten years of experience teaching fifth grade. She is part of a three-unit departmentalized team teaching science to all the fifth graders. English and social studies are taught by the other fifth-grade teachers while Anne teaches the remaining subjects to her homeroom group. The target group used in the study was her homeroom group.

RESEARCH PROCEDURE

As teacher-researchers, we conducted a preliminary survey involving over 300 students. As a result of this experience we had to face our lack of understanding about higher order thinking and our lack of data (see Teacher Misconception section). We went back to the drawing board. We talked about specific higher order thinking skills we felt were lacking in our students. We felt that students lacked the ability to conceptualize and apply the concepts of time to new situations. We were concerned with several specific areas including time management; the comparison of past, present, and future; and the analysis of cause and effect of past, present, and future frames of reference. Finally, we hoped to provide students with a broad-based schema of time that would serve as a foundation for conceptualizing curricula fundamentals based on time.

We questioned whether student inability to be successful in understanding curricula concepts of time is due to cognitive immaturity or is due to lack of background experiences. Stiggins and Conklin (1992) found that higher order skills are not understood and/or not assessed by teachers, and there is commonly a mismatch in thinking skills, level of instruction, assignments, and tests. We therefore took care in our research not to label or categorize student thought but rather to listen closely to students' own descriptions and for commonalties among those descriptions.

Students were first asked to share their concept of time by answering four survey questions: 1) What is time? 2) What is the oldest thing you've ever seen? 3) Why is time important? 4) How is time measured? (see Appendix 4A, p. 78). After establishing this base of knowledge we presented students with experiences to broaden their concept of time. Some activities were common to all age groups, others were unique to the class. These 15 activities are described in Appendix 4A along with student responses. Each age group had a different focus for the time-thematic unit: fifth graders studied present time and its measurement, ninth graders focused on time of the past using geologic time. All students were asked to keep track of their time for one week and interpret their time using a circle graph. Students were then asked to share their knowledge with each other in answering some follow-up questions and developing a time poster. In their homeroom, ninth and fifth graders presented their collaborative time visual to the class while being video-taped. This tape was exchanged and reviewed by the other age group in the collaborative team. Students used a teacher constructed inquiry instrument (fashioned after the Kelly Walsh/ Casper College research being conducted simultaneously) to wrap-up the project (see Appendix 4A).

BASELINE

In the initial, baseline developing stage of our research, the majority of students saw time as an agreed upon set of units of measurement used to organize their activities and lives. Students from both age groups made statements resembling these examples: "A type of measurement in the form of hours, minutes, seconds," "A guideline for your day. Something that tells you when it's time to do something. Something to keep you on track," or "The measurement of past and present." Time was represented in the present frame of reference with minimal focus to the future and virtually no acknowledgment of time in the past. Responses seemed to be

sharply divided between the logical uses for clocks and calendars and the more abstract concepts associated with time. However, these abstractions were simple clichés such as "time is life," "time is a state of mind," "time is moments of your life," or "time is money! Something that goes by far too fast." Only one ninth-grade student was able to display a broad concept of time in stating, "Time is memories. A measurement of existence. Time is the past, present, and future. Time is more than a thing. It's a state of mind." Initially, students' perceptions of time were narrow in focus and based in the present.

All students initially saw the value of time as a necessary tool in structuring society. They depend on time measurements to meet friends, go to school, get up, and schedule their days. A few students said that "time is life" and a handful said that "time is NOT important." Several students alluded to time controlling their lives in stating, "If there wasn't time, people would lounge around all day," "We'd all be confused if time was no [sic] here," or "Because our life is time, and our life is dependent on time." The majority of student concerns with time had to do with how they, as individuals, use time as a tool to do the things they want to do, or to be with people they wanted to be. By understanding the concept of time and extending it to an application of time management, students could see wise time-management as a means of getting what they wanted.

STUDENT TIME SCHEMAS

In the discussion below, we relied heavily upon an extensive document called *Benchmarks for Science Literacy* (1993). In an effort to define the substance and character of education for today's children gearing for tomorrow's world, *Benchmarks* was developed through collaborative efforts of over 150 "in-the-trenches" teachers and administrators as well as science association staff. Science, mathematics, and technology standards describe student abilities by grade level (2, 5, 8, and 12). There is an entire section of the document discussing the relevant and extensive education-research literature supporting the practitioners insights. What follows is not meant as an endorsement of this single document but as a recognition of the extensive information compiled to offer insight to teachers. This comprehensive document delineates grade-level, student-thinking abilities and thus is a relevant correlate to our discussion of student schemas.

Fifth-grade time schemas

Initially, the fifth-grade student perception of time focused on time pieces and the divisions of time. Clichés were referenced to express the relevance of time. Fifth-grade students have an egocentric view that influences their concept of time. These students relate time to concrete events and, generally, only to those events which they themselves have directly experienced. They are grounded in the here and now as is reflected in their concept of past, present, and future being a human's time span. To draw an analogy, students perceive time as a series of snapshots from the past, present, and future. Only a few of the pictures have captions that serve as detailed descriptions of those events. Most of the snapshots have the student as the subject of the photo. Fifth graders are complacent with the rules of home, school, and church that manage their time and provide structure to their concepts of time. Although they are not able to actualize the thought, fifth-grade students believe good and deserving people obtain their goals through wise time management. Moral thought strongly influences fifth-grade student thinking.

Curiously, *Benchmarks* (1993) frequently omits discussion of student thinking/learning abilities for students below the ninth grade when the time reference is for anything other than the present. For example, in the discussion of historical perspectives, *Benchmarks* identifies two qualities students of science history must have (1) know or at least be able to follow the science involved, and (2) be able to grasp the main features of the prevailing view at the time. *Benchmarks* goes on to discourage lower-grade educators from presenting simplified versions because those introductions may promote misconceptions. However, if younger students are

involved in collaborative study of the contribution, then it is likely to be understood by the student. We see our research directly tied to these *Benchmarks* findings: younger students have egocentric, moralistic views that make it difficult for them to understand the prevailing view at the time. The fifth-grade/ninth-grade collaboration was successful at expanding student time frames. Our findings are in agreement with *Benchmarks*.

Ninth-grade time schemas

Initial time schemas held by ninth graders generally referenced time in the same concrete ways as the younger students' schemas: time is a unit of measurement that helps us organize our lives. The initial relevance of time was that it provided structure and regulated one's life. Given the opportunity to explore some nuances of time, ninth graders readily considered time spanning across a continuum. These older students could conceptualize time from different points of view. They see the linking of the past, present, and future, and recognize cause and effect events along this continuum. Past time is associated with concrete and visual events. Present time may exist only for a millisecond or cover the entire period of human existence on earth. Future events are grounded by plausible and logical considerations. These students want to be in total control of their own time and resent outside influences that control their time. Continuing the photo analogy used above, ninth graders have a very rich and diverse photo collection across the time span. The boundaries of the collection go to the far extremes. Most photos have detailed captions and are arranged chronologically to reveal a connected storyline. Photo images are realistically portrayed, but the student does not have to be in the photo. Images can be displayed using a variety of timing and linking strategies; fast-forward, reverse, time-lapse, or pause. Time management is of value to students, but they do not see the direct connectedness to real-life career skills and so do not invest much effort in developing this reflective tool. Only a few ninth graders interpret time without concrete associations (time is memories).

Despite this unit of study on time, ninth-grade students adamantly adhere to the concept that time controls peoples lives. The general logic is "time controls peoples lives, no one can change time, time can change people." Students have the concept that our existence on earth is predestined "because time controls how long we live (or) die" and "when you die someone else is ready to take your place." A few students recognize they have control over their future: "time controls peoples lives, but if you use that time wisely your future will be as you want it." One student alluded to the technological future: "time controls people because people do not have the ability to control it—yet." These results, which indicated the importance of environmental conditions to the existence and extinction of species in any time, were not communicated well. Students did acknowledge that they have choices in the management and outcome of their own time.

Intertwinings

Throughout our study of time, there were always student-initiated discussions of technology and evidence of reasoning skills. The students linked time to technology and used reasoning skills to understand time. Because technology and reasoning skills are intertwined in student thought, they should both be considered in our mapping of time schemas.

Benchmarks (1993) relates that there is a very small body of research on student knowledge and applications of technology. The limited research comes from samples of students outside of the United States and is focused primarily on high-school students. Like *Benchmarks'* research-based summaries, our research found that students appear to understand the impact of science on technology, but they do not always appreciate the impact of technology on science. Through the discussion of time it was quite clear to us that fifth-grade students recognized that technology, like language, ritual, commerce, and the arts, is an intrinsic part of human culture. Technology is quite clearly associated with pollution and weapons in our conversations with students. We similarly find agreement between our research

and *Benchmarks'* when ninth graders articulated that technology usually affects society more directly than science because it solves practical problems and serves human needs; and, fifth graders state how technology extends the ability of people to change the world. Inventiveness is very central to a fifth graders thinking about technology whereas ninth graders recognize that technology may not be able to insure human survival. Our research with fifth- and ninth-grade students parallels the nature of technology thinking abilities described in *Benchmarks*.

The reasoning skills a student uses helps identify how he or she processes new information into existing schema on any particular topic. Classroom discussions and debriefing sessions allowed students to cite evidence, justify, and elaborate on their thoughts. For fifth graders this logical discussion was a challenge in and of itself. Ninth graders, however, questioned the evidence, and the validity of the evidence, being used in the justification. The Boreal toad discussion and the time-log activity (see in Appendix 4A) clearly showed that ninth graders choose to process information, if they perceive it to have meaning in the real world, unlike the fifth graders who are still willing to be idealistic dreamers. Fifth graders frequently process information through analogies. The initial use of time clichés and the development of the collaborative poster visuals gave evidence to this thinking pattern. With the posters, students formed analogies by comparing the concrete evolution of technological tools (cars, weapons, time pieces) to their concepts of past, present, and future time. Ninth graders expressed frustration with these posters in saying they tried to work out a bigger picture of time giving evidence to the broader reasoning skills held by ninth graders. Ninth graders hold a sophisticated level of reasoning when they can illuminate the insignificance of humans when viewed as one component along the span of the earth.

Significant events modifying students' time schemas

Several activities, discussed below, were reported to be meaningful by the students. Marzano (1994) identifies tasks as meaningful to students if they are application-oriented tasks, long-term tasks, or student-directed tasks. While these research explorations (see Appendix 4A) meet Marzano s criteria, what is noted here are tasks the students viewed as important and useful.

Tabulating and evaluating their own time using the time recorded on their schedules was a powerful activity for the fifth graders. The majority of the fifth graders had never examined how they use their time, and they found it insightful. Most were shocked at the amount of time they spent sleeping! For the most part students accept how adults structure children s time with only four percent of their time (ranging from 0% to 18%) being compliance actions. These compliance activities are described as going to watch their siblings or performing undesirable chores: the child is not the reason and purpose for the activity. This time investment calculated out to be less than an hour a day. The students labeled these compliance activities as "protest" on their pie graphs. Fifth-grade students, in a moralistic way, see time management as the way to earn their goals. They enjoyed the collaboration and discussing the commonalties of the pie graphs with the ninth graders. Since fifth graders are egocentric in their awareness, only experiences directly tied to themselves are meaningful.

The adding machine tape activity provided "a better concept of measuring, scaling things" and "I learned Eras [sic] good." The aeronautical maps were mentioned because they "taught me about what people flying airplanes use" and "measure distance in time." Although no specific content learning was mentioned, several students really liked the collaborative work with the fifth-grade students. I suspect the student who wrote, "I know more about dinosaurs, and now I know (even) more, and it makes me feel smart and others think I'm smart" is expressing the feeling students have when they collaborate. I think the collaborative effort was successful because everyone had something unique to share and that made them look and feel smart; they developed some positive self-esteem. In reference to the Tate Museum trip a student writes, "Going to the Tate made me understand that past was not only yesterday but

millions and millions of years before that," and another states "dinosaurs weren't the only kind of cool animals from a lot of years ago." The time schedule was mentioned as being meaningful, but students did not elaborate. As a result of classroom activities, students reported that the concepts of extinction, biodiversity, millions of years ago, and reverse time developed into new images for them. Obviously these concepts and activities should be incorporated in future teaching/learning experiences.

Fifth graders can see the importance of time management to achieve personal goals. However, they view time management from a moralistic viewpoint implying people with self-control are good at managing their time and will receive what they want as a reward for their disciplined actions. One fifth grader aptly summarized the significant schema change for the majority of fifth graders, "time is a BIG thing."

Most ninth-grade students can synthesize the concepts of geologic time and time management and apply them to their own life. One student now looks at time with a broader view, "I will think further now. Look at decisions with a big picture." Another states she will "be more open to realize that we all shall die someday." Others state, "I will use my knowledge of time to motivate me to mold my future now, while I can." "I will use everything I learn from past mistakes not to have the same mistake in the future." The study of geologic time and time itself has been internalized by most of the ninth-grade students.

As a result of this unit students have a new vision of themselves in relation to the world. Simply stated they say it "made me feel smaller." "It makes me feel like humans on earth will merely be specks in time." But one student notes this realization "helped me appreciate what is here know [sic]." Adolescents tend to view themselves as immortal and perhaps this concept has been dampened by this unit of study.

WRAP-UP FINDINGS

All participants struggled with the wrap-up questions. They were uncomfortable with the open-ended format of the survey, but with encouragement they managed to provide insight into their own thinking. What follows is a summary of their collective thought by age group.

Time in the past

For fifth-graders, generally, the frame of reference for past time is relative to the existence of humans. During class discussion students expressed value in the present (1995) but referred in almost a condescending way to preceding times (such as the 1960s and 1970s) when "people did not have much need to organize." Fifth graders noted that in the past, "time wasn't thought of." Some students expressed knowledge-level understanding of specific past events such as "dinosaurs died" and "no electricity." However, the fifth-grade schema generally equated the past with events specifically tied to their own experiences, and in the broadest sense they saw the past as events during human existence.

When asked what they learned about time in the past, ninth-grade students gave a broad picture of the earth's geologic history. "The earth is 4.5 billion years old," "the past was measured by millions of years," and "I [did not] realize the Earth is this old," indicate that students understand the basic concept and measurement of geologic time. However, students also wrote statements that indicated breadth of understanding. "Before I was born and before humans were created there was land and only water...," "...long ago plants and other life organisms were created," "we started very primitive and simple," "...the saber-toothed tiger didn't live with the dinosaurs," "that almost everything went extenkted [sic]" portray an understanding of the earth as a dynamic, ever-changing environment supporting a variety of life forms over distinct periods of time. The concepts of evolution and extinction are integrated with the concept of geologic time. Only one student made the

distinction that changes in biodiversity [using index fossils] are what geologists use to indicate changes in geologic time periods. Ninth-grade students have expanded their thinking about the past by giving a more elaborate description of the past and show a sense of a-long-time-ago as being not just yesterday but millions and billions of years ago.

Time in the present

Fifth-grade student schemas of present time are firmly focused on their own world. One fifth grader acknowledged that "we are more occupied by time" and realized our regimentation by time by stating "[the] world depends on time for everything." They are fascinated with how technology will "[help] people think of new ways to conserve time and expand it by the invention of new gadgets." Fifth graders are well-grounded in their concept of the here and now.

Ninth-grade students expressed intrigue with the realization that the present results from the past. "The present is what is happening at that very moment, for example, when I wrote down the beginning of this sentence, it was the present and right now it's the past." "We have become more complex." Students noted that the present may be a millisecond, as indicated above, or millions of years by stating "[present day] man has only been around for 2 [sic] million years." These students have a broader sense of present time, "there's more to it than watches and clocks," and by knowing how long it takes the earth to rotate, time can be used to measure distance in "...degrees and seconds." Students recognize that the present will change, and the future will not be anything we can predict. One student notes, "We may not be here forever. Everything else went extinct why can't we?" Students have a broad concept of present time and articulate how the present is tied to the past and the future.

Time in the future

Future perceptions of fifth graders are not very realistic but cover a full range of events. When paraphrasing the class discussion that technology increases human life spans which creates a larger population that stresses and limits the resources needed for human survival, they express optimism with "no limit [to] what is possible to help medicine" and pessimism, "too much technology to handle." The future is again a description of events and only one student related present action to the future in expressing "we will become extinct if we continue on the same path of destruction."

Time, change, and future are all intertwined to a ninth grader's way of thinking. Change is inevitable. Several students noted that the future depends on present actions "if in the future I don't go after my science grade, I'll never become a paleontologist," "to plan my future and don't go on a daily basis," and "...we can use things from this age to make things more progressive in the future." Technology is very much a concept of the future. Although students never directly state that technology will allow humans to live beyond the time we are environmentally suited, they imply it in their writing. Here are some examples: "We will [sic] be here? or will we be all dead, or in space," "In the future we will have outdone ourselves. Time will be nothing or everything. We will be so into computers and things." Students are connecting their experiences with geologic time and the time-log activity to build a broad concept of futuristic time.

Universal concepts of time

All students had trouble articulating a summary, or universal, concept of time. Many failed to answer this wrap-up question, or they wrote down the first thought that came to mind. A few students were able to synthesize their thoughts. "Time is but an ever-changing concept, you can learn today what you did in the past to help you in the future." "Things are only on the earth for a very short time compared to all time." "Through time, humans and other organisms have become more complex. The sky is not the limit anymore." Despite the fact that only a few students displayed abstract thinking with this question, most of the students who failed to write in this section had shown integration of thought during

previous explorations (see Appendix 4A). Perhaps the question was unclear to students.

TEACHER MISCONCEPTIONS

We embarked on this research knowing that many teachers believe alternative assessments require students to use more higher order thinking skills than traditional tests. So we questioned "What are those skills and how do we know whether a student has the ability to utilize higher thinking?" After pulling together fourteen activities to assess higher order thinking by students and administering those activities to over 300 students, we concluded that we had no information about how students apply those thinking skills in real learning situations. We had no true picture of how students process information.

In going through this process, we, as teacher-researchers, discovered a misconception in our own thinking. We believed that not until about age twelve did students develop the cognitive ability to engage in abstract thought, and prior to that age students would not be cognitively ready for the demands of higher order thinking. Our collaborating colleagues challenged our thinking, they believed children of all ages can be involved in higher order thinking. However, it appears that teachers from different parts of the state, who were trained at different times, have an identical misconception. It seems, then, that many practicing teachers have a misconception of when students are cognitively ready to be engaged in higher order thinking.

Higher order thinking skills are difficult to define. Resnick (1992) provides an insightful discussion of higher order thinking skills and provides the following definition:

> Higher order thinking involves a cluster of elaborate mental activities requiring nuance judgment and analysis of complex situations according to multiple criteria. Higher order thinking is effortful and depends on self-regulation. The path of action or correct answers are not specified in advance. The thinker's task is to construct meaning and impose structure on situations rather than to expect to find them already apparent (p. 140).

Higher order thinking skills were thought to be developmentally related, but in reviewing the works of Piaget, we challenged our concepts about developmental cognitive abilities. Piaget notes children of all ages are capable of some level of abstract thought although the abstract thinking of a younger student is not as sophisticated as the abstract thinking of an older student. Resnick (1992) notes, "The most important single message of this body of research [on higher order thinking] is that complex thinking processes... [examples cited] ...are involved in even the most apparently elementary mental activities" (p. 141). She further recognizes that "all of this implies that 'basic' and 'higher order' skills cannot be clearly separated" (p. 141). She classifies higher order thinking as "an 'enabling skill' for learning and thinking." We recognize abstract thought (the ability to synthesize and apply information to make new associations) as one of the many varied skills that can be termed higher order. Our own research shows students at both the fifth and ninth grade level are capable of higher order thinking including abstract thought. Given an opportunity to express themselves, and a little guidance on what is expected, students of all ages are capable of more than knowledge-level thinking. It then appears that teachers may be limiting student opportunities for learning by not incorporating higher order skill practice at all grade levels because of their misconceptions of cognitive developmental stages.

Resnick (1992) discusses the incongruency between educational theory and practice. "In fact, the term 'higher order' skills is probably itself fundamentally misleading, for it suggests that another set of skills, presumably called 'lower order' need to come first." Resnick further states, "This assumption—that there is a sequence from lower level activities that do not require much

independent thinking or judgment to higher level ones that do ...implicitly at least, ...justifies long years of drill on the basics before thinking and problem solving are demanded." And concludes, "Indeed, research suggests that failure to cultivate aspects of thinking such as those listed in our working definition of higher order skill may be a source of major learning difficulties even in the elementary school." Resnick calls for a "reconceptualization of the nature of thinking and learning... (to) guide educational work." (p. 134) with the belief that if general thinking skills were identified and effectively taught, it would improve learning across the curriculum.

CONCLUSIONS

Time is an important concept for students in any field of study. Traditional curricula teach students how to interpret time measurement on clocks, but the broader nuances of time are lacking in our curricula. Students may have difficulty understanding specific curricula because they have a limited time schema for reference. Teachers also assume that students know how to apply the concepts of time to real-life; for example, we expect students to know how to manage their own time, and seldom do we give guidance in this skill. Unlike students from past years who simply memorized the information without meaning, the students involved in this study actually learned the geologic time scale and its significance. Similarly the concept of measuring aeronautical distance in units of degrees, minutes, and seconds did not seem to be difficult for these students. Had there been time left in the school year, we would have quantified and compared learning by these students who studied time thematically, with students who have not had this type of training. This comparison may be an extension of our research for next year. Since time is frequently an experimental variable poorly understood by most students, we would also like to monitor students' ability to use time in experimental design and graphing results. We believe students with a broad schema of time will be more successful in these tasks.

Student schemas initially made references to time as being tied to clocks and watches and generally focused in a narrow frame of reference (yesterday, today, tomorrow). These students have expanded their concept of past, present, and future to cover millions of years. Students originally equated the present as "now" but have expanded their ideas to include such concepts as the emergence of modern man as "present" along with a microsecond also being "present." Students understand the inter-relatedness of time with biodiversity, evolution, and extinction. Students can conceptualize time being divided by a variety of units from milliseconds to eras and understand how time can be a measurement of distance. Although students have not actualized how environmental conditions control life spans and still see life as a predestined existence, overall, the thematic study of time enhanced student understanding of time and diversified their time schemas.

By understanding time, students have demonstrated a better understanding of themselves, past, present, and future. Students have a better understanding that time management enhances one's ability to reach his/her goal. Fifth graders found time management to be a means of empowering themselves to be independent people. However, neither student group displayed any disciplined changes in their behaviors to reach goals during the course of this research. Fifth graders are multi-goal oriented and are still enthusiastically willing to explore their creative and natural talents. Ninth graders are much more self-limiting in the goals they see as possible. The ninth graders were very clear in expressing a new concept of human insignificance as a result of better understanding the past.

There is a clear difference between fifth grade thinking and ninth grade thinking. Fifth graders see past, present, and future as discrepant events, as dots on a time line. They see relevancy to these events only as how it affects them personally. Ninth graders, however, have a sense that time is a continuum. Unlike the fifth graders, the older students express how events and times are related by cause and effect. Perhaps because of this association of cause and effect, the older students can recognize conditions that shape

their destiny. Fifth graders rely on concrete images and analogies to process information while ninth graders depend less on concrete images and more on the connections with plausible, real life events. Both age groups are capable of understanding time in a broad sense, but the older students show more sophistication and detail in their thinking.

The intertwining of a student's time schema, technology awareness, and reasoning skills gives evidence that conceptualization of time is a higher order thinking skill. If a student can conceptualize time at any level of sophistication, then there is evidence that a student has utilized higher order thinking skills. The evidence that both fifth and ninth graders can engage in higher order thinking challenges teacher misconceptions that this level of thought is developmental. However, the depth and breadth of abstract thought does develop over time. As teachers, we classify time as abstract thought; students see time as "a BIG thing," as one fifth grader put it so succinctly.

Our research has four general implications for teaching. First, teachers should not assume students have sufficient background information to accommodate new learning. Initial student time schemas were very narrow even though time is a common discussion point in daily life. Secondly, teachers need to select materials and experiences that are meaningful to students. Meaningfulness for fifth graders is anything that personally involves them in the collection and presentation of their findings. For ninth graders meaningfulness is tied to the application of information to real-life needs and interests. Thirdly, teachers need to engage students of all ages in higher order thinking while recognizing that the degree of student sophistication increases with maturity. Stiggins and Conklin (1992) show that even though teachers believe they are engaging students in higher order thinking, 74% to 100% of study and discussion questions are recall. And a last implication for teachers is that assessment must be tied to what the students have actually experienced and learned. Students with a limited concept of time, for example, have trouble discussing the significance of a geologic time scale or selecting time intervals to graph.

REFLECTIONS

Student Feedback

The enthusiasm, motivation, and buy-in for this project was overwhelming. Once this broad picture of time was presented, students automatically contributed because everyone knew something about the topic. The really exciting part was when students would share in class, "Did you know...?" The most fascinating part of the study for the fifth-grade class was the biological clock study with animals. Some of the kid talk was uncomfortable for classmates. When talk focused on too much technology destroying the world, students squirmed and became defensive. Morality issues were raised when medical dilemmas and zero population entered the conversation about the future. One fifth grade student expressed his understanding of how to responsibly shape the future, "Too many people are the cause of the entire world's problems, and we must change that."

Collaboration is a very powerful teaching tool. Collaborating between schools was terrific. The kids are still talking about when they got to go to the junior high school. When students knew they were going to share their time log with ninth graders, the quality of work improved and justification of the activity became essential. Several poorly functioning ninth grade students made significant changes in their studies and appearance in preparing to work with the fifth graders. One such student, who typically wore ratty jeans and a baggy T-shirt, arrived on collaboration day wearing a stylish dress and shoes. She has regularly reminded the teacher of ideas and activities that resulted from that collaborative experience. For the fifth graders, the videotape sharing worked very well. They talked to the TV while viewing the ninth grade reports, and engaged in a good dialogue, as if their partner were present, listening and engaged in the conversation. The video exchange by the ninth

graders was not taken seriously, but the one-on-one was very important to them. We set up the collaboration so that everyone could be an expert in his/her own unique area. The fifth-grade students now have an internal bond with their junior high partner. This was a real success, and we hope to be able to develop a long term collaborative program next year. The value of this multi-age activity is immeasurable.

Collaborative Research

This research has been a stressful experience for the teacher-researchers. It is exciting to actually have partners who are interested in researching, improving education, and trying new approaches in the classroom. However, it has been difficult for us all to coordinate our timing. The collaboration with others across the state has been painful at times due to lack of information from us and our inability to articulate our intentions. At times the comments were harsh, challenging us to go beyond our comfort level.

Anne's Reflections

Engaging myself in activities similar to my students', I found I was spending much of my time on the road, waiting for kids, and appointments, and an excessive amount of time in meetings!!! Often a memo would have been sufficient. Writing goals and keeping track of a time log was very powerful for me. The collaboration with another teacher has been the best part of the entire project. I have found that I can share some frustrations, as well as the same joys, in my classroom, and I will not be judged or put on the defensive. One of the biggest messages I got was that when students are empowered, they will rise to the occasion. When students play an integral part in what is happening in the classroom, the ownership and the quality of work is remarkable. I am now willing to risk more.

Andrea's Reflections

Time exploration was the unit that would never end. Several of the activities were useful to students, but presenting them all in one unit of study became overwhelming for us all. In the future I would like to incorporate the time log concept at the beginning of the year. I would introduce it as a study skill on time management and a tool to reveal to students how their time is really being spent. I felt the activity that students did at the end of the year was fake data, and I had no way to verify if that was the case or not. By doing the activity at the beginning of the school year, students will be more inclined to use the activity and the results for their benefit. I would, then, be able to re-visit the activity and findings throughout the year, making it a better learning tool. The pie-graphing needed in this activity is on the edge of ninth-grade student skill. I gave the assignment as homework but had to do lots of individual coaching to get the results. In the future I would do this as a class activity after an introduction to graphing. Although I will change the time log activity as noted, I plan to offer the study of geologic time pretty much the same as I did this year.

On the personal side, it is a real treat to have found a colleague that is a true partner. Philosophically, Anne and I are similar; she has strength where I am weak. I've learned a great deal from her as she asks questions I've never thought to ponder. She always does what she says she will do. I think it's rare to find this kind of partnership, and I hope that we will continue to work together. Collaboration has been a wonderful experience.

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APPENDIX 4A

What follows are descriptions of class activities in which students participated during the course of this study. Their inclusion is NOT to provide a lesson plan but rather to show the richness of curriculum-based opportunities for developing time concepts. Time inquiry can be accommodated in a variety of curriculum areas (i.e. life science, earth science, social studies, life skills,...). These activities were teacher-developed activities that were presented and modified based upon the perceived needs of the classroom students. Local interests and resources were highlighted (Tate Museum, Boreal toad, and regional aeronautical maps).

The activities reflect opportunities given in approximately one semester. Most of the activities were completed during one 45 minute class period. Some specific references and detailed lists of time and materials are included, but these inquiries could be reproduced using a wide variety of resources. We want to emphasize the inquiry process, not specific content.

Classroom discussion and listening to kid talk are important components to this project. While students participated in these activities, we watched their level of engagement, overheard their discussions with peers, and facilitated whole-group discussions to develop concepts. At the conclusion of each activity, students debriefed about their learning. When things were not working, we listened to what students said and modified the direction to accommodate student needs.

Geologic Time

Traditional teaching/lecture was used to present information about the characteristics of the earth at various times during the earth's geologic history with the ninth-grade classes. Additional student exploration activities were given to students to broaden their experiences. These supplemental activities are described below.

Clocks

In discussing the success and failure of teaching geologic time with a colleague at the end of last year, the colleague speculated that students have only the concept of present time because they are exposed only to digital clocks. He is a thirty-eight year veteran in teaching ninth-grade earth science. I felt he had a valid and interesting hypothesis.

Students in both age groups were asked to draw the first clock that came to mind. They were then asked to draw a clock showing past (half-past three) and future concepts (quarter 'til three). They were then surveyed on the types of clocks present in their world, their personal preference for time pieces, and reasons for their preference.

The vast majority of all students had face clocks as their first image of a clock. Students were successful at communicating "past time." Future time was fairly easy for most students to interpret. Students are exposed to both face clocks and digital clocks in their homes. The majority of students preferred digital clocks because of the ease in telling time accurately. However, students have had experiences with face clocks. They associate them with the concept of time, and understand how to read them in past, present, and future context. Student focus on present time can not be attributed simply to digital clocks.

Goals

All students were able to express perceptions of future time by noting personal five-, ten-, and fifteen-year goals when writing their answers to written questions. Ninth-grade goals were traditional: doing well in school, going to college, getting a good job, and having a family. A good job meant one that paid a good salary. While the ninth-grade goals were specific, detailed, and focused on personal strength, the younger students still had lofty goals. Students had a

very clear vision of where they wanted to be in the future but did not always see the connectedness of the present to the future. For example, a fifth grader, who wants to be a fashion designer, the first woman president, or a trainer for the Hornets, stated a year end goal of "run the 50 meter dash in less than 8 seconds" even though she doesn't like to run and is 30 pounds overweight. Another student stated his goal as "strate [sic] A's" at the end of the year, in five years "Driving my dad's Ford," in ten years "Be in collige [sic] and learn to be a mechanic," and in fifteen years "Be a pro in golf." This clearly shows the loftiness of young student's goals, poor sequencing ability, and total lack of connectedness between personal actions and their long-term goals. Few students focused toward the future. However, one fifth grader demonstrated his clear vision of time and action by stating the following goals: "straight A's" by the end of the year, in five years "to be on a varsity sports team," in ten years "go to college to learn and make it on a sports team" and in fifteen years "have a family and be on some kind of pro sports team (soccer, baseball, basketball)." This student showed a clear focus and realization that action results in the desired outcome over time. Generally, fifth graders see no connectedness of the present to the future but ninth graders do understand the relationship even if they can not actualize their knowledge.

Negative time

Ninth-grade students were to chart significant events on a piece of adding machine tape. Events were charted with a scale of one centimeter equal to one year. Students had to calculate the amount of tape needed and to decide on their own significant events.

The purposes of this activity were three-fold. First, this activity was intended to have students think about time from a personal perspective. Secondly, it was intended to have students conceptualize negative time, going back in time. Thirdly, the activity helped students conceptualize significant events as being markers of time, not regular annual events.

All ninth-grade students were successful with this activity. However, several students were asked to re-think their time-line and make sure it reflected time on a scale of years ago. This thought process was not automatic but came easily to most students. Significant events in a student's life are not always pretty events. Numerous students shared times of first sexual abuse or significant battering. Because of this honesty, students did not share their personal time-lines with the class, and the class discussion was teacher-led to focus on the analogies to geologic time divisions. Students had few recollections of time more than five years before present but had numerous significant events in recent years. This pattern led beautifully into a discussion of why we have little information about the pre-Cambrian time but numerous smaller divisions of geologic time nearer our present day.

Geologic time and adding machine tape

A variation of this activity—using adding machine tape to measure events in the past—is described in the ninth-grade text, *Modern Earth Science* (1989). Ninth graders are given information showing the eras, periods, and epochs of geologic time. They are then instructed to make a time-line using adding machine tape and a scale where one millimeter represents one million years. The first challenge students face is to determine how much adding machine tape to use as they deal with the concept of time and scale. After the various geologic times are plotted on the tape, significant changes in the geology, flora, and fauna are added to the tape.

The purpose of this activity is to allow students to visually conceptualize geologic time. Geologic time is not based on equal intervals but on significant events occurring on earth (geologic, flora and/or fauna). Students are able to visualize that all times are not equal in duration, and that human presence on earth has been for an insignificant period of time.

Students performed this activity in groups of three. They enjoyed the activity, the discussion of scale, and the visual aspects of the

project. When it was completed, the tapes were displayed collectively and variances in tapes justified.

Time-log and pie graphs

All students in this study were given a blank time schedule for one week (Appendix 4B, p. 84). They were to record their activities and acknowledge whether the activity was a personal choice or one mandated by others. After one week of data collection students were to summarize their findings and make a pie chart to share with other students. Ninth-grade students were asked to make a pie chart of geologic time as well.

The purpose of this activity was to personalize the study of time for students. Students had to keep track, tabulate, and evaluate how they spent one week. The real-life significance of studying time was to gain some insight into managing one's own time. The purpose of the pie graph was to help students visualize, then analyze their own time.

The results, the visual display of how the week was spent, were a surprise to the majority of students. For both groups of students, the majority of their time is managed by someone other than themselves. The amount of non-productive and wasted time was astounding. Most students were amazed at how much of their time they spent sleeping.

When the fifth-grade students discovered they were going to share their time-log with the ninth graders, the quality of work improved. A real break-through came to one fifth-grade student as a result of this activity: If he could spend the same amount of time swimming as he does watching TV, then he'd be much closer to his goal of being an Olympic swimmer. A mother of a fifth-grade girl remarked that the pie graph was a real shocker because it made her realize how much time her fifth-grade daughter was in charge of watching her younger daughter—one daughter was raising the other.

Unfortunately, the insights from the ninth graders were not useful. The activity was time consuming, and students were suspected of fabricating data because they didn't see the relevance of this activity; consequently, their time-log data were not very significant in the discussion. The analogous activity with geologic time, however, was meaningful to them since many commented on the enormous amount of time classified as pre-Cambrian and the small percentage of time encompassed by the other time classifications.

The math skills needed for this activity were significant. Students were given a circle showing degrees and percentages as a guide (Appendix 4B). The fifth graders worked on the development of the pie graph as a class activity; ninth graders did it as a homework activity although most needed individual help to complete the chart. Ninth graders did not understand the conversion of percent to circle degrees. Once the students had constructed the pie graph, both fifth and ninth graders could easily interpret it.

This activity proved to be very powerful. It was insightful to students and parents and pushed students to gain new skills and a visual understanding of time.

Index fossils

To help students relate life forms to different geologic times, ninth graders were presented with pictures of index fossils from various time periods. Each student was then given a unique stratigraphic column showing the index fossils in a new order. They were asked to identify the index fossils using their reference handout and explain what geologic events might have occurred to make the strata have a non-normal presentation.

This activity was a bust. Few completed the task (even at the level of simply noting that a given fossil pictured was associated with a given time period). Only one student actually interpreted what was happening from a geologic standpoint to produce such a stratigraphic column.

Field trip to the Tate Museum

Ninth-grade students were given a two-class-period opportunity to explore the Tate Museum on the Casper College campus. They had three tasks that they were to accomplish during the time period. The first was to tour the fossil preparation laboratory and visit with the technician about the process and training needed to prepare Wyoming fossils. The second required students to describe the earth's environments during the various geologic times after viewing the "Walk through Time" display cases showing fossils, pictures representing what the habitat looked like, and maps showing what was happening to the land we now call Wyoming. The third sent students on a scavenger hunt searching for specified items in the museum to encourage exploration of key fossils and minerals in the museum. The students worked in self-selected groups.

Paper cup adaptation

Ninth-grade students were given a straw, paper cup, two paper clips, and tape to create a paper-cup critter. The students' task was to create an animal that would have fed in the algae beds during the earth's early history. They designed their animals. After presenting their critter to the class, and detailing the special structures it had to make it well-suited for living in an algae environment, the students faced a major climatic change. Gravel rocks were scattered on the floor and students were told that the food source had changed from algae to some "rock-like" food. They were then instructed that their critters were to feed on the new food source, but the critters had to feed on one rock at a time and must return to their home base with the rock before they could feed. Only the critter could pick up the rock and transport it—no human-hand help. At the end of the feeding frenzy, rocks were counted. Animals were charged five rocks for loose body parts and ten rocks for a lost body part. Discussion then followed as to how animals must change physically to meet new situations and how such changes occur at a cost. Some critter species survived through adaptation, some critters became extinct.

Boreal toad discussion

Ninth-grade students were presented with questions about toads, ice age climate, and the present day Snowy Range Mountains. Resources in the room included numerous biology textbooks with information on the life cycle of toads, field guides for amphibians and reptiles, maps of Wyoming, and earth science textbooks for information on the ice age. After searching for information to answer seemingly unrelated questions about toads and the ice age, we had a discussion about reasons for the endangerment of the Boreal toad, a native toad to the Snowy Range Mountains. Students generated a variety of hypotheses about the decline of the toad population, and class discussion focused on gathered information to verify their ideas. This was a whole-group, teacher-facilitated, discussion.

The primary purpose of this activity was to help students explore how climatic conditions, perhaps due to changes in geologic conditions of the earth, create changes in the flora and fauna of the earth. Secondarily, this activity intended to help students realize that humans may not be the primary reason for all species decline, that some may be "natural" declines due to climatic changes.

Fifth-and ninth-grade collaboration

After completing the classroom exploration activities, fifth- and ninth-grade students met for a 45 minute period at the junior high to discuss time: past, present and future. They had a worksheet to guide their discussion and were expected to create a visual poster representing that discussion. Students were randomly assigned to groups which included one person from each class, since each class had a different focus, and each student had unique information to contribute.

The purpose of this activity was to allow students to peer-tutor each other as they developed a holistic and broader concept of time.

The results of this activity were amazing. The collaborative aspects of the task were significant for both the fifth and the ninth graders, as discussed in the Reflection Section of this research. A few collaborative teams had only a shallow focus (model-T cars, present-day cars, and cars of the future) but nearly every group had a significant discussion of how one time period is influenced by another. Poster themes included:

- Technology will help us live in a future for which we are not now adapted to exist (extinction, adaptation)
- History repeats itself (repeated wars in Asia over time)
- By learning from your past mistakes, you can shape your future
- Some future culture will exist on top of strata where our present culture is buried on top of index fossils of the past
- Technology is killing us (our dependence on the tropical rain forest for new medicines will cause us to overuse and destroy the resource, thus altering the world we live in)
- Time has no beginning and no end, it is constant as long as the earth's movements stay the same
- Microscopic life forms advance to forms that survive on land, dinosaurs exist and become extinct, will humans advance into a new life form to survive in space or will we become extinct?
- Time is a continuing cycle
- The development and the sophistication of concrete objects over time

These poster themes clearly show the meaningful dialogue which occurred between the fifth- and ninth-grade students. This activity allowed students to see the relatedness of past, present, and future. The ninth graders later commented on how smart the fifth graders were and that they had learned a great deal from them; plus, they also enjoyed being mentors for the fifth graders. The ninth graders also reflected upon their own past, what they were like as fifth graders, and speculated that these fifth graders would be better off than they were today because the fifth graders were smarter.

Fifth-grade research projects

A list of time topics was placed on the chalk board to help students select a time topic to research. Research topics were in six categories: watches and clocks, time frames of other cultures, calendars, circadian rhythms, biological clocks, and theories and measurement of time. Students self-selected a topic and worked with other students who had chosen the same topic. Research resources, which included encyclopedias, library non-fiction books about time, and the social studies textbook, were made available in the classroom. Students were then asked to share at least one interesting finding about their topic with the class. Students later shared their research with the ninth graders in collaboration.

Video Summary

Fifth- and ninth-grade students used their posters to help them orally summarize their collaborative efforts in front of the video camera. Videos were then shared between classes for students to validate each other's summary of the activity. Ninth graders saw little value in producing more than a quick summary and prepared by reviewing the poster just prior to taping. Fifth graders were constantly assessing themselves in preparation for the videotaping. Some wrote down what they were to say, others memorized, and others rehearsed with a partner—the timely and immediate feedback was useful and meaningful to them as they prepared.

The video allowed students to demonstrate their increased concept of time. All students displays were unique and portrayed their brainstorming ideas in ways that were meaningful to their small collaborative group. Students showed great ownership in this by their obvious efforts to gather background information, and they

expressed confidence when presenting to the class. When the fifth-grade students knew that the audience would be the junior high students, with whom they had worked, their intensity, proficiency, and articulation escalated to a much higher level than would normally occur in the homeroom setting.

Aeronautical maps

Ninth-grade students used aeronautical maps to measure distance with a scale of minutes and seconds. This activity followed a lecture presentation on latitude and longitude and how distance that the earth rotates can be measured using time. We also talked about how time is used in every day life as a way to tell other people how far away something is (e.g., it's 15 minutes to the mall, Denver is five hours away).

The purpose of this activity was to have students see time as a measurement of distance and location.

Students loved finding local Wyoming sites using minute and second grids on aeronautical maps. The ninth graders claimed that they would have been lost if the fifth graders had not taught them about time zones. Students had minor difficulty, at first, using a coordinate system to pin-point a location but quickly got the hang of it. Last year's students struggled with the concept that these ninth graders took in their stride.

APPENDIX 4B

What follows are key worksheets/activities used in the project. Students were overwhelmed by their lack of information about time, and truly had such limited background information, that they did not know what kinds of inquiry questions they might have. For these reasons, the teacher-developed questions below were used to identify and redirect student learning.

Students' written responses to these questions were used extensively in our project. The initial survey questions were asked before students explored any time concepts and are the source of our baseline information. The wrap-up questions were used to identify new schemas students had developed from the exploration activities. The other examples are included because they were significant activities that provided us with insight into student thinking.

Initial Survey Questions About Time

1. What is time?
2. What is the oldest thing you've ever seen?
3. Why is time important?
4. How is time measured?

Collaboration

- Write your name and the names of your partners in the space below.
- As you introduce yourselves, tell where you went to 5th grade and share a memorable experience that you remember from 5th grade. (Spend only 3 to 5 minutes on this).
- The 5th grade students have been doing some research on time. The research your partner(s) did was on the topic(s):
- With your partner(s) list possible wrong ideas people could have about this topic. (What are the misconceptions that people have about this topic?) Spend about 5 minutes doing this.
- Using your time-logs, compare your findings with your partner(s). (15 minutes?)
- How does the time percentage in school compare between your time-logs?
- If there are differences in the percentage of time spent in school, is there a reason for the differences or is it a mathematical error?
- How do your results compare for time sleeping?
- How do your results compare for time spent watching TV/ free time?
- Make a summary of how kids spend time. (What are the similarities and differences of how kids spend their time?)
- Each team has a poster-board and markers. Using collective knowledge, each team is to make a visual to show its understanding of time. Brainstorm some ideas, make sure everyone contributes, and plan your visual to answer the question below.
- How do we use knowledge from the past and the present to guide the future?

It's time to wrap it up!!!

Read the following definition of learning:

Through learning we become able to do something we never were able to do. Through learning we expand our ability to create, to understand, to be a part of, and to contribute.

1. Using this definition of learning, give examples of what you have learned about time …

   in the past;

   in the present;

   in the future;

   universally (a big picture or concept).

2. Which activities helped you

   (A) do something you could not do before?

   (B) change your thoughts (mental image) about time…

   in the past?

   in the present?

   in the future?

   universally (a big picture concept)?

3. How will you apply your new knowledge about time to shape or contribute to the future?

4. Explain how your understanding of time helped change the way you see yourself in relation to your world?

5. Does time control peoples' lives or do people control time? Explain.

A COMPARATIVE ANALYSIS OF TEACHER AND STUDENT PERCEPTIONS OF LEARNING

Sandy Leotta, Nancy Branchie, Elizabeth Horsch, Colleen Burridge, and Julie Horsch

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A COMPARATIVE ANALYSIS OF TEACHER AND STUDENT PERCEPTIONS OF LEARNING

Our initial study was an attempt to identify indicators of learning. Five teachers in separate classrooms in two educational settings were involved in this research. Our preliminary findings indicated that students could identify activities that promoted learning but were unable to formulate a clear definition of what learning is. Without a common understanding of what constitutes learning, students and teachers were unable to agree about whether learning had occurred. We formulated a second research question that asked, "Do students and teachers hold the same view of what learning is and what evidence is acceptable that learning has occurred?" Two important findings emerged from our study. Students perceive learning as it relates to the tasks they can perform, and they link the evidence of learning to relevance and the connections they make in their own lives. As teachers, we tend to expect students to show us direct evidence of learning by tasks completed or presented within the classroom. Our findings have led us to challenge commonly held notions of what constitutes valid assessment. We found that, according to students, much of the real learning that occurs may not be measurable within the confines of our classrooms. Finding common ground between what students consider real learning and what teachers perceive as meaningful assessment may be an insurmountable obstacle. Perhaps developing and implementing sensible and productive activities which result in significant changes in what students know and can do may be the only reasonable compromise.

THE EVOLUTION

Introduction

The focus of our study, as we initially conceived it, was to identify indicators of learning and to evaluate whether teachers and students were in agreement over those indicators. We began by administering a survey in our classes at the end of a unit of study. This survey asked the students to identify the activities they believed had been most useful in promoting their own learning. The students had no difficulty identifying particular activities they considered important in helping them learn, but as we examined these results, we began to question whether a list of activities was indeed acceptable evidence that learning had occurred. Our questioning led us to wonder if we and our students shared a common understanding of what constituted learning and if we could cooperatively agree on the evidence that learning had occurred. We then formulated a second research question and gave our project a new direction.

Research Question

Do the perceptions of teachers and students differ about what learning is, and what is acceptable evidence that learning has occurred?

Description of Individual Research Settings

Our research team consists of five members. Four members of the team teach at Kelly Walsh High School, one of two high schools in Casper, Wyoming. The school population of about 1,200 students in grades ten through twelve is predominately white and middle income. Approximately sixty per cent of the school population enrolls in college after graduation. The high school has a traditional structure with an eight-period school day, each period consisting of fifty minutes. Students must complete seventeen course hours for graduation, including two course hours of social studies and one of science.

Three members of the team teach in the science department, and one team member teaches social science. Sandy teaches biology, Nancy teaches biology and anatomy/physiology, and Elizabeth teaches chemistry. Colleen teaches a U.S. history course in the social science department.

The fifth member of the research team, Julie, teaches in the biology department at Casper College. This community college serves about 3,700 students per semester. The median age of the students is approximately 30 years, although the figure varies widely from year to year. The college offers general education, college transfer, career, avocational, and developmental courses. It confers an associate degree in multiple disciplines, and several baccalaureate and master's degrees in programs through the University of Wyoming-Casper College and the University of North Dakota-Casper Site.

Julie's research was conducted in her pathogenic microbiology class which serves primarily college transfer students seeking degrees in nursing, pharmacy, physician's assistant, and medical technology. Students seeking to enter a professional school in health services also enroll.

General Research Procedures

Each researcher used nontraditional instructional methods which engaged the students in defining problems, proposing study procedures, executing the study independently or in small groups, and formulating conclusions. Since the student population and the academic discipline were unique to each research setting, the instructional delivery system and the learning atmosphere were likewise unique. The research was conducted during the spring semester of 1995 in all five research settings.

All five team members used the same survey instruments and interview questions. Methods used to gather information about teacher and student perceptions of learning included: 1) Survey Instrument A, a preliminary survey to determine which activities the students considered useful in promoting learning; 2) Survey Instrument B, a questionnaire that proposed a definition of learning and asked students about their concept of learning based on that definition; and 3) Survey Instrument C, free-response interviews of some students (see Appendix 5A, p. 105). Teacher reflections were also used to gather data on the teachers' perceptions of learning and assessment.

All five team members met on a weekly basis during the spring semester to share information and to coordinate the research procedures.

DESCRIPTIONS OF EACH PROJECT

SETTING A: SANDY LEOTTA'S SOPHOMORE BIOLOGY CLASSES

Introduction

Our high school offers general, regular, and advanced level biology classes, and at least one of these sophomore classes is required for graduation. I completed the research in the regular and advanced level classes, as these were the levels assigned to me this year. There were 105 students in the study.

For more than ten years of teaching high school biology, I have micro-managed each minute of the period so that students were busy and controlled. In class, I was the person accessing, synthesizing, and utilizing interesting information from different sources. After working on this research project, I have restructured my class so that it is the students who have the opportunity to dig out their own information, make sense of it by themselves, present the material to an audience other than the teacher, and analyze how well they have done their job. Each of these steps is a project in itself, but this study focused on how well the students had learned, from both their perspective and the teacher's.

Research Procedure

A preliminary study was done asking students to distinguish from among a set of learning activities those which they liked and those from which they learned. Classroom discussions, field trips, teamwork, projects, and team presentations were most often cited as being activities from which they learned. It was this survey that finally convinced me, after 15 years of teaching, that students truly do not learn from a classroom activity that I had routinely used, such as questions at the end of chapters in the textbook.

A series of somewhat open labs was then assigned to students. Lab write-ups which were not acceptable were handed back to be fixed until they met the teacher's standards. These labs allowed the students to dig out their own information and make sense of it themselves, yet there was no audience other than the teacher, and the student was not allowed to evaluate the final product. These labs were modified to allow editing by the students' critical friends and the students themselves.

The organ dissection lab (fondly known as the blood and guts lab) was one of the open labs assigned during the course of the research project (outlined below). It was adapted from the work of elementary teacher Diane Carey and was particularly successful in allowing the students to take charge of their own learning.

Organs for this assignment were collected during the fall semester. Students were given extra credit for bringing in organs from antelope, deer, elk, or moose. We accepted almost anything except the stomach. These were frozen for use in this lab. A list of the organs available for dissection was kept and a week or two before the dissection, students (in groups of two) signed up for the organs. Organ dissection required two days: one day for the whole mount drawings and cuts, and a second day for the tissue samples to be stained and drawn using 40X and 100X microscopes. Students were then expected to present their findings to the class using visual aids.

ORGAN DISSECTION LAB OUTLINE

Part 1 - Structure of the organ

Step A.

- Name the organism.
- Name the organ system.
- Name the organ.

Step B.

- Research the structure and functions of the organ.
- Present a page of information and drawings. List at least two sources.

Step C.

- Draw the organ as a whole mount. Include all structures. You must have a page of information and drawings. List at least two sources used.
- Sketch lines on your drawing to show where you are going to cut.
- Label these lines with letters.

Step D.

- Draw a view of your organ from the cuts you have made. Label as many parts as possible.

Step E.

- Write a conclusion explaining how your organ's structures relate to their functions. You must discuss at least five parts of your organ.

Part 2 - Tissues

Step A.

- Make slides of at least two different types of tissues.
- Draw two to three cells and label any parts you can see.
- Give the magnification of your drawings and any stains you have used.

Step B.

- Explain the function of each cell type. How does this cell help the organ with its function?

Step C.

- Give a three-five minute explanation to the class of what you have learned about the structure and function of your organ. Include a visual aid showing the parts and functions of the organ and drawings showing the parts and functions of at least two cell types.

Findings

The most impressive results of this lab were the quality of the research, observations, and drawings, and the obvious curiosity and awe apparent in most of the reports. Students were motivated to research the organ before dissection; they overcame any squeamishness during dissections due to their curiosity; they were proud to present the results of their research and enjoyed feeling competent while answering questions from their classmates. Most initial reports required fixing, as students found it difficult to link structure to function, the most important concept of this lab.

Students felt they were very much in control of what and how they learned, even though this lab is rather structured. I felt this lab had the best balance of openness (the students were in charge of their own learning) and structure (they felt sure of what was being asked of them).

Students cited their ability to answer questions from classmates about their presentations and their ability to relate structure to function from their own experience, not from finding answers in a book, as evidence they had learned.

Discussion and Reflections

The most difficult part is to open up the assignment so the students feel in control of what and how they learn, yet give enough direction so they know how to proceed and how to present their learning. It is also difficult for the teacher to manage the teaching load of approximately 115 students, an average load for most high-school teachers.

Many sophomores, particularly the advanced students, have a preconceived notion that they will be expected to memorize many facts in science, and feel competent to do so. They are confused and unsettled when asked to complete less-structured assignments which require conducting research, analyzing data, drawing conclusions, and presenting results. They want to know what they are supposed to do so they can do it exceptionally well. It takes some practice for these students, and they don't like it much at first. However, once they understand the new expectations, they work harder than I have ever seen students work.

An important part of the process is that the students know they will receive feedback from their peers before they present their work in front of the class. As they review the work of others, they become more motivated to improve both their work and their presentations. An even greater motivation would be an outside audience, but I did not get that far this year.

An important facet of this process is that the assignments must be important enough to merit all the time. The above changes have improved the quality of learning in my classroom, which leads to the question "How much and what are the students learning from both the student's and teacher's perspective?"

The process can be uncomfortable both for the teacher and the students until the results are seen. My students are beginning to gain an appreciation for the study of the living world. It would now be impossible to finish assignments in 50 minutes because students find they must use materials from the library, the classroom, and the good books hanging around their homes. Although they must use afternoons and weekends to finish assignments, they are now willing to do so.

Working in this research setting has convinced me that for teacher research to work, teachers at each site must be working on the same question. The buddy system—meeting with someone on a regular basis—is imperative.

SETTING B: NANCY BRAUCHIE'S ANATOMY-PHYSIOLOGY CLASSES

Introduction

My research was conducted in three anatomy/physiology classes. Anatomy/Physiology is an optional science course for students at Kelly Walsh High School and is comprised of juniors and seniors with average to above-average academic ability. The unit we were studying was the muscle-skeletal system. The five goals I had for this unit were:

1) identify the bones of the human skeleton;
2) identify the muscles of the fetal pig;
3) relate the muscles of the pig to analogous muscles in the human;
4) relate the muscles used to move bones in a specified direction; and
5) develop a project on muscle kinesiology, where the bones, muscles, and joints which carry out a certain body action are identified, related, and discussed in a manner that is understandable by the layperson.

Research Procedure

The instruction during this unit was not what I would consider teacher-directed. Students were provided with reference material, anatomical charts, and worksheets with bones and muscles identified on them. I had a dissected pig model that was available for them to view to assist them in their identification of fetal pig musculature. I was available for consultation and to answer questions. No lectures or direct instruction were provided.

Students worked with a partner or formed small groups of three to five to accomplish the goals. Identification of the muscles of the fetal pig was done through dissection of a pig with an accompanying dissection guide, observation of the model pig, or through consultation with me.

Identification of the bones and bony processes was accomplished through the use of the textbook, anatomical charts, and worksheets. Student groups also matched the bone or process listed on a flashcard with an actual skeleton. This seemed to be an effective method of learning the bones, particularly when they challenged each other in a game-like format.

I utilized two different types of assessment tools to measure the goals listed above. Practical exams were the first type of assessment given which consisted of students identifying a required structure on the human skeleton or the fetal pig. The second assessment consisted of a kinesiology project in which students chose an action performed by the body (throwing a baseball, kicking a soccer ball, etc.) and then identified the muscle groups used to carry out each step of that action. This project required the students to recall muscle locations and skeletal structures, and, also, to think about how muscles move bones and what role the muscle plays in the action (flexor, extensor, etc.). I felt the students had to build on the basic concepts already acquired and apply the information they had studied.

Findings

My students had no trouble identifying those activities which they considered to be most conducive to their learning. Cited most frequently were working as a team, completing the kinesiology projects, participating in classroom discussions, using thinking and logic, and performing the dissections. Student comments (from an anonymous written survey) that support these findings follow:

- These activities are involved! Not just someone telling you what to write down, but rather grasping at a thorough understanding of something and writing down brief notes for yourself.
- The projects helped create a mental picture for what I was learning.
- Working as a team helped because I was able to have others' input and ideas. Sometimes others say, do, or explain something in a way that triggers my memory. It also helps to be in a group because then I don't feel so overwhelmed.
- Usually, if I think a process through, it means more than if someone just tells me. I also understand and am able to recall information the same way I learned it.
- Experiments and projects prove to me why something is the way it is. I don't like having something just told to me. I like knowing it is true for myself.
- The kinesiology project made me transfer knowledge of the pig muscles to the human and make relationships between both. Working as a team is helpful, if I don't understand, my teammate might.

My students were as adept at identifying those activities which they felt were the least beneficial to furthering their understanding of the goal areas. Stated most frequently were using worksheets and taking tests. Some interesting quotations follow:

- I feel these are the least helpful, because when I do textbook work for a worksheet, I merely copy down the information. Very rarely do I think about and try to understand my answer. Tests are much the same reason. When I study for a test, I end up just memorizing the information, and I end up forgetting it when I've completed the test.
- Usually for tests I remember the information for a short time and after the test is over the info isn't important.
- I would complete the worksheet, but I was just looking for the answers, not learning them. I wouldn't usually pay attention to what I was finding and writing down.

When asked to supply evidence that they had learned, student responses seemed to fall into two major categories, with a few other interesting, isolated remarks. Students cited as evidence of learning that they were able to identify and locate the muscles and bones of the body, which they were unable to do previously. The second common response was that they were able to relate this information to occurrences in daily life. Some students stated they were able to participate in conversations with college students, doctors, and sports personnel because they knew what these people were talking about. Others stated that they thought about the muscles they were using when they engaged in a physical activity or were sore following a work-out of some kind. Several students stated that they now have a visual picture of muscles and bones and how they work together. Other students cited that they understand the relationships and connections between various body systems.

Reflections

From the standpoint of our research question, "Do the perceptions of teachers and students differ about what learning is and what is acceptable evidence that learning has occurred?", I have mixed feelings. Many of my students stated that they could now identify structures they were previously unable to identify. I have a tendency to dismiss this as real learning. However, as this was one of my goals for this unit, I am partly to blame. In thinking about this issue, I realized that a certain portion of the knowledge base must

consist of this information in order to move on to higher levels of thinking, so maybe I am too harsh in my dismissal of this as real learning. If one had no prior knowledge in this area, acquiring an understanding of basic anatomy would represent learning.

I am excited about those individuals who cited "forming relationships between body systems" and "creating visual imagery" of anatomy as evidence of learning. In this instance, we are altering mental pictures and creating or reorganizing schema. This, to me, is the essence of learning because changes as fundamental and substantial as this will lead to a different perspective about the human body. So, my mixed feelings are those of pride and uncertainty. As I think and write about this research question, I am wondering if any two people can agree on what learning is and what are acceptable indicators that it has occurred. So much of this issue is tied up with personal interest and ability, prior knowledge, cultural differences, and philosophies of education that I feel it could be a difficult issue to resolve.

SETTING C: ELIZABETH HORSCH'S CHEMISTRY CLASSES

Introduction

This research was conducted in two chemistry classes. Both classes were composed primarily of junior students who had elected to take an accelerated class in chemistry (n=37). One of the two classes was a two-period block class of twenty students. This class met for one hundred minutes each day. The students completed two years of chemistry in one year and received two credits at the end of the two semesters. The other class met for fifty minutes each day, and the seventeen students completed one credit in chemistry in two semesters.

Research Procedure

Beginning in the fall of 1995, the two-period block class was conducted in a less structured, more student-directed format. Since the research project was initiated in the spring semester, the students in this class had previous experience in directing their own learning. The instructional mode in the single-period class included both traditional textbook-centered units and units in which the students were expected to participate in designing their own experiments and monitoring their own progress. For the purposes of this study, I decided to use a more traditional, textbook-centered unit in the single period class and a self-directed exploration unit in the two-period block class. I was interested in comparing the students' concepts of learning in a self-directed instructional setting versus a more traditional instructional format.

The topic of both the self-directed unit and the traditional unit was equilibrium. In the self-directed unit, ten general questions about equilibrium were posed as the basis for the exploration. Students were expected to work in teams, and each team was to use the multiple resources available in the classroom to identify a chemical equilibrium system for study. Some teams simply performed experiments that were described in the literature, while other students chose to design their own experiments to study the system they had selected. When the teams had completed their experimentation, they were expected to revisit the ten questions. As they attempted to apply their experimental results to answer these questions, they frequently initiated small-group discussions and consultations with me. They were expected to create a formal written report of their explorations and to present their study to the class. We video taped each team's presentation, and the students were encouraged to view and critique their own work.

The other chemistry class was expected to perform a series of assigned laboratory and hands-on experiments dealing with equilibrium. They were assigned specific readings in the textbook, homework, and review assignments from the text. This class had

just finished a less-traditionally-structured unit in which they worked in teams, designed their own investigations, and shared results with other teams. This experience apparently influenced them to engage in frequent independent explorations and extensions beyond the assigned traditional laboratory experiments. Because of this orientation toward independent work, some of the students elected to disregard the suggested textbook assignments and to rely on multiple references and resources. As a result, the instructional setting became much less traditional as the work on the unit progressed, and it more closely resembled the instructional setting in the two-period block class. My original plan to compare students in a traditional setting with students who were given more responsibility for their own instruction and learning did not materialize. The data collected from the surveys and interviews were very similar in both classes. The instruction plan for the equilibrium unit follows.

CHEMISTRY IA - UNIT OUTLINE

Topic: Equilibrium

Text Reference: Chapter 13

Additional Resources:

- Film on Equilibrium
- Laboratory manuals, reference texts
- Computer disks
- The instructor. (You may ask for a discussion or consultation at any time.)

Goals:

- To develop a conceptual understanding of equilibrium
- To be able to apply your understanding of equilibrium in the investigation of selected chemical systems

Study questions:

1. Why does equilibrium occur?
2. What is "equal" at equilibrium?
3. Why is the equilibrium constant important?
4. How are the equilibrium constant and the equilibrium expression related?
5. How do the equilibrium constant and the equilibrium position differ for a particular reaction?
6. Why can pressure be substituted for concentration in reactions involving gaseous systems?
7. Can you explain why the concentration of solids and pure liquids do not appear in the equilibrium expression?
8. How can K be used to predict the tendency of a reaction to occur?
9. How can the understanding of equilibrium be used to quantify the chemical concentrations at a given equilibrium position?
10. What are the effects of changes in concentration, temperature, and pressure on a system that has reached equilibrium?

Tasks:

To demonstrate a conceptual understanding of chemical equilibrium: 1) by responding to the ten questions; 2) by selecting a chemical reaction that will achieve equilibrium and investigating the characteristics of that system, including the impact of changing conditions upon that system; and 3) by identifying and solving one question from those in the back of the chapter which illustrates each question.

Procedure:

1. Form a team of three people.
2. Devise a plan for achieving the goals of the unit. Submit this plan for review. The plan should include a proposed work assignment and a time line.
3. All requests for supplies must be submitted in writing.

Evaluation:

1. Each team member will keep a dated daily log of his/her activities each day. <u>This is a requirement</u> and must be ready for inspection each day.
2. Each team will submit a final report of the achievements of the team. This must be typed.
3. Each team will present an oral report to the class describing its investigations and findings. These presentations will be videotaped.
4. Each team will complete a standard test on the topic of equilibrium.

The students completed this unit of study in approximately twelve hours of class time. They reported additional hours spent outside of class finding references, designing their study, and formulating their group report.

Findings

The surveys and interviews were conducted after the students had completed the unit on equilibrium. Results of the preliminary survey indicated that students had no trouble identifying the activities they considered to be conducive to learning. Classroom discussions and working as a team were cited most frequently, followed by creating their own experiments and using thinking and logic. This list of four items was common to both instructional settings, the traditional and the self-directed.

When the students were faced with supplying evidence that they had learned, however, their responses generally fell into the category of mastery of skills or operations. Typical examples were: "I designed an experiment," or "I can calculate the value of the equilibrium constant," and "I could tell the class about my experiment and answer their questions."

They also simply listed topics: "I know about equilibrium," and "I understand about concentrations." They overwhelmingly cited things they could do as evidence that they had learned.

Only ten percent of the respondents provided answers that I could accept as evidence of conceptual change. These students described equilibrium as a system and indicated the response of the system when they physically changed some conditions of the system. One student provided a powerful image of his mental ability to work with the concept of chemical equilibrium : "I can create a working model in my head of how an equilibrium system works, and when you ask me a question about it, I can alter that system to answer your question."

Reflections

During this unit, many of the students created interesting and even elegant experiments to answer their own questions about an equilibrium system. Their conversations about what they were observing and the interpretations they offered for the observed phenomena were thoughtful and even sophisticated. When they were faced with a direct question about whether they had learned anything, however, they generally slipped into cataloguing activities as the evidence that they had learned.

As I reflect on the students' responses as they were faced with the direct query about what they have learned, I wonder if real learning is so highly individualistic and so dependent upon present and past experiences that we cannot formulate the appropriate classroom instruments to measure it. The questions that we pose for students

to answer may fall far short of probing the depth of their understanding and may, in fact, completely miss the essence of what they know. Perhaps we simply will have to settle for providing ample resources and multiple and diverse experiences which allow the student to explore many ways of knowing. And we will honor their own perception of what they can say or do as a result of those experiences as the real measure of their learning.

SETTING D: COLLEEN BURRIDGE'S MODERN AMERICAN STUDIES CLASSES

Introduction

History classes involved in this research project were two regular level modern American studies classes of approximately 25 students each. This is a required class for junior level students and covers American history from World War II to the present. Students have the option of enrolling in general, regular, or advanced level classes.

Research Procedure

Surveys were conducted after a unit on civil rights and again after a unit on the justice system in America. Oral interviews were also conducted after the justice unit. Both units were taught in a fairly non-traditional approach with a minimum of teacher-directed instruction. Planning and researching projects and presentations took up the bulk of the time. Project options in the civil- rights unit included the option of reading the book, *Black Like Me*, by John Griffin, and participating in a class discussion, completing a comparative analysis of at least two civil rights leaders of the twentieth century, or conducting oral interviews of people affected by or involved in the civil rights movement. In addition, all students were given a reading assignment. A test consisting of multiple choice and fill-in-the-blank questions was administered at the end of the unit. This test included material covered in class and in the student presentations.

The justice project involved fewer product options (they were all required to complete a research report) but more content options than the civil rights unit. There were a couple of small worksheet-reading type of assignments and a bit more directed instruction, primarily concerning how current law is interpreted regarding the *Bill of Rights*. A test was also administered at the end of this unit over material presented in class as well as material covered in the student presentations.

Students were required to keep a journal, and a major part of both units became class discussion which focused on the journal question for the day. Although the journal questions did not always revolve around the topic, an attempt was made to utilize questions which tied into the unit. These questions were designed to stimulate higher order thinking skills and were never only knowledge-level. Students were required to write their thoughts in their journal and were given the option of discussing their thoughts out loud after they had recorded them.

An example of a journal question during the civil rights unit was, "Do you believe racism exists in your community? What evidence would you use to form the judgment?" One of the questions during the justice unit focused on the symbol for justice (the blindfolded-robed woman holding a sword and scales). The symbolism of the form was discussed. The students were then asked whether they believe this symbol is appropriate today, and they were given an opportunity to draw one they believe would be appropriate.

Findings

From the surveys, I found that students did not believe they learned more from projects. They seemed to see these as another "disconnected" activity. As expected, few believed that they learned from textbooks, worksheets, or test activities. An eye-opening finding for me was that 68% of the students listed class discussions as an activity that was helpful to learning. Their reasons were primarily because they felt they could hear what other people had

to say and could voice their opinions. Sometimes class discussions helped them see things from a different perspective and occasionally their opinions were changed. I am intrigued and challenged by this finding. I wonder if they really learn or do they just like to listen or talk. I wonder whether this appears to be a powerful learning tool because it's easier for them, or is it powerful because they see it as the most relevant? These are questions I will continue to ponder.

Oral interviews after the justice unit were very positive. Six students were interviewed; five of them were able to identify things they learned during the unit. Upon asking "How do you know you learned?," the most consistent responses were that they were able to discuss/use their information outside of class. One particular student asked for a special conference with me to tell me how much he had learned during the unit and related the following experience: When the police considered arresting him the night before our conference, he was able to use the information he had learned in class to hold them accountable for seeing that his constitutional rights were not violated. His perception was that his knowledge of his rights was enough to keep him from being taken into custody. One student who shared that she didn't typically like history classes opened up with the following response:

> I learned about the courts and the significance of the Supreme Court decisions. I never realized how much they impact society... I am more interested... I understand the amendments were written for our protection and not for people's selfish needs. I understand why there can't be government religion in schools. I see the controversy over the First Amendment and that the right to exercise free religion does not mean unlimited rights to exercise. I learned that cyperspace exists and what our society is capable of doing that our government can't control....Most important though, I've learned that I've always had the answer or believed the answer was out there if only someone would just go get it. But now, I realize that there are real problems that are serious and difficult to solve. Sometimes there isn't an answer...I see how things in the past have helped shape how things are today. I know I have learned because I understand the significance of issues rather than just facts. Things like politics are more clear—they used to be so foggy. I know I have learned because I can use the information I have learned in other situations. When I watch the news, I understand more.

Another student responded that she knew that she learned because she was able to share her project information without notes and was comfortable answering questions that she had not necessarily been prepared for. Others mentioned that when a subject came up on the news, in other conversations, or in their classes, they were able to transfer their learning to another situation.

The sixth oral interviewee said she learned nothing from this unit because she couldn't learn "that way," meaning a research project approach. She found it very frustrating that I didn't just give her a book and an assignment. She was a bright student and struggled continually in my class to the point of dropping it during the last quarter.

Reflections

I really expected that the students would do very well with the project approach, that they would be able to find a relevant issue and consider that great. At first, I was disheartened because the great majority didn't feel they had learned from the projects, and the quality of the projects supported that impression. I was surprised when some students said they really felt they learned best from books and worksheets or teacher-directed activities. I didn't think anybody would like those activities.

I will continue to develop class discussions and to focus on making them learning-oriented rather than an opportunity to simply voice an opinion. I will also continue to develop more options from which the students can choose. I have broadened my perspectives in that choice doesn't simply imply that students will be allowed to choose a topic on which to write a research paper. I want to continue to develop a variety of options for each activity, and while I cannot guarantee that significant learning will occur, I will create more opportunities for it to happen in a variety of ways.

I concluded the year with a unit on the Vietnam war which attempted to address this new approach. Students were provided with a list of possible projects, including creating a collage, writing a poem or song, creating an audio presentation of protest songs, writing an analysis of the POW/MIA question, and investigating changes in America or Vietnam as a result of the war, as well as student-generated options. Different projects were assigned a point value depending on the depth of thought required to complete the project. Students were required to earn a minimum number of points. Students were also given the option of taking a standard, book-generated, multiple-choice test to acquire some of their project points. Although I wasn't able to conduct surveys at this point in the year, I was able to make some observations. Many of the students chose the test to meet some of the project requirements. Although few of them actually studied for it, they were willing to take the test because they seemed to perceive this as an easy way to get points. A few students did read the book carefully, scored well on the test, and seemed to feel they had learned well from this approach. I did observe that some students got very involved in their projects and did more than the minimum amount of work required. One student became very engrossed in a fictional story she was writing about a soldier in Vietnam. She brought her story in daily and continued to edit and add to it for over a week.

This student's experience epitomized many of the thoughts I was grappling with. She commented that she loved this approach because she never learned history from a book and she was a terrible test-taker. She seemed very excited about what she was leaning and told me that she learned a great deal. Despite her enthusiasm, I was not quite so convinced. In looking at her story as a product of her learning, I was not as certain as she that learning had taken place. This brought me back to our original question when we launched this project, "What are acceptable indicators of learning?" Perhaps I will not be able to observe indicators of learning within the walls of my classroom. Maybe learning is an internal affair that occurs subtly over time. Perhaps our job as teachers is not to measure learning by some clearly articulated set of guidelines but to open doors and allow students to expand their thinking in hopes that there will be opportunities for them to make learning meaningful to them.

SETTING E: JULIE HORSCH'S PATHOGENIC MICROBIOLOGY CLASS

Introduction

I first became aware of the disparity in perceptions of learning between students and instructors when I was in graduate school. This disparity became even more obvious when I became an instructor myself. The impetus for initiating this research in my own classroom evolved during conversations with other instructors who saw classroom research as an essential tool and from a desire to align what I thought I was teaching with what the students thought they were learning. My study was conducted in my pathogenic microbiology class. Sixteen students were initially enrolled in this course for the 1995 spring semester, and fourteen students completed the course. Eight of the students who completed the course were male, six were female.

Research Procedure

At Casper College, students enrolled in pathogenic microbiology are required to have completed a course in general microbiology.

The pathogenic microbiology course curriculum is divided into lecture and laboratory sections. In lecture, organisms that cause disease in humans are surveyed. The laboratory curriculum emphasizes techniques used to identify these disease-causing organisms. Traditionally, laboratory exercises are instructor-driven. The tasks are assigned, completed, and graded with little student input.

This semester, however, I proposed an original research problem as the basis for the laboratory work. The research problem was originally suggested by the general microbiology instructor based on a statement in the general microbiology textbook. Paraphrasing, the text stated that the high incidence of multiple-drug-resistant nasopharyngeal *Staphylococcus aureaus* organisms in hospital settings could be directly attributed to the universal practice by health service practitioners of expelling air from the end of a syringe filled with an antibiotic prior to injection. This statement implies that these small quantities of expelled antibiotics are inhaled by the person giving injections and that repeated exposure to these antibiotics was a contributing factor to the development of drug resistant *S. aureus* organisms in the nose and throat of hospital personnel.

I presented this statement to the students the first week of the semester and then gave them a week to gather information about the organism and the drug resistance typical for that organism. In the next week, the class defined their research question: "Does repeated exposure to microaerosolized antibiotics contribute to the development of drug resistant *S. aureus* in persons who repeatedly inhale small quantities of aerosolized antibiotics?"

The students then began to develop the procedure they would use to research the question. To do this, they formed small (three-four person) lab groups for discussion and then came back together as a larger group to collaborate. The research design portion of the study required the students to access journals, lab manuals, and texts to gather information about the organism and techniques to identify it. In addition, it was necessary for the students to access current articles dealing with the pathogenicity of strains of the organism typically found in hospitals. The students selected the types of samples they would collect (in this case, nasal swabs), decided how to collect and transport the samples, and defined the groups of persons to be sampled. The project design took approximately two more weeks to complete.

After the research design and procedure was agreed upon and completed, the students began to gather samples. The sampling portion of this project required the students to research protocols for the use of human subjects as well as procedures and protocols in the various health care facilities where sampling was done. Sampling, processing of the samples, identification of *S. aureus*, and the antibiotic resistance associated with the cultured organisms occurred over the next ten weeks. The students then wrote up their results and submitted a draft of the paper to me for review. The final paper was submitted during the last week of lab. Additionally, student journals were submitted for review.

Findings

When Survey Instrument A was administered (Appendix 5A), students clearly were able to identify what they did that helped them learn. The activities most frequently identified included working as a team, creating an experiment, and using thinking and logic. They also identified those things which were not perceived as being helpful. Reference materials in the lab and their journals were cited most frequently as unhelpful in learning. Students indicated that the use of a journal for self-evaluation and reflection was a new concept in a biology course, and they were not sure how to use the journal as a tool to assess learning. Regarding references, one student rather bluntly stated that use of the reference books needed to be explained as the student "used [them] one or two times, but never did figure out the particular thing we were looking for."

In Survey Instrument B (Appendix 5A), students tended to identify skills as the primary/only evidence that learning had occurred,

despite being given a definition of learning. Additionally, when asked to identify activities that enhanced learning, most students were unable to separate parts of their research project from the whole. They did not recognize specific activities within the project as pivotal learning experiences. Instead, the credit was given to the entire semester-long research project. One student commented that "the whole project was my learning experience." When asked to identify experiences that changed perceptions of the world , the class (with one exception) agreed that working in a group was a powerful tool. While one student was openly irritated with the group nature of the project, the others agreed that working in a group significantly and positively impacted their learning.

In the class discussions of the research project, the students indicated that they experienced a good deal of frustration at times during the semester. However, as they assessed their learning at the end of the project, they were confident that they could now problem-solve effectively, something they were unable to do at the beginning of the semester. This impression was markedly reinforced when I reviewed the final exam (see Appendix 5B, p. 109). The responses to this question were extraordinary.

The students understood how to approach and solve a problem using the skills and knowledge gained in class.

Reflections

Approaching the lab portion of this course from a research perspective provided some unusual challenges as well as some outstanding results. The original lab question regarding the association between repeated exposure to microaerosolized antibiotics and the development of drug-resistant microbes in the nasopharynx was well suited to this lab course. The students could pursue a real question while mastering concepts and skills traditionally covered in a pathogenic microbiology laboratory. Emphasis was placed on sampling techniques, isolating microorganisms from a mixed culture, transferring and maintaining pure cultures, and identifying antibiotic resistances. Conceptually, the students studied, in depth, the characteristics of gram positive organisms, the use of selective and differential media, the immunological techniques for identification of organisms and the mechanisms by which antibiotic resistances develop within a group of microorganisms. This is an important list of ideas because it provides the student with a framework for diagnostic microbiology.

The lab did much more than cover a list of traditional topics. The students had a chance to define a purpose for learning a technique or understanding a topic. They were able to test new ideas and adjust or revise their approach to the problem when something went wrong. The students had to think about what they were trying to do in order to accomplish it.

Parts of the lab were extremely frustrating. The politics of using human subjects and sampling in a medical care facility nearly stopped the project early in the semester. The students (and the instructor) expended considerable energy to insure that the sampling procedures met the guidelines for several different administrative entities. Technical problems also surfaced. At one juncture, the students discovered that the combination of the media used to maintain their cultures and the immunological test used to confirm the presence of the organism were likely to produce inconsistent results. This discovery resulted in retesting one hundred cultures. Perhaps the most unnerving event occurred when the students began to look at their data. The research data did not support the conclusion many of the students had anticipated. This was apparently so unsettling that some students turned in a draft of their final report stating that no conclusions could be drawn from their data. It took several class discussions before the students were able to accept that the research was valid even though the data did not support their original assumptions.

The real power of this kind of instructional procedure might well have escaped me had it not been for the final exam I used for the course (see Appendix 5B). This assessment instrument was designed

to measure how well the students could solve a problem using skills from lab and knowledge from lecture. During the semester, emphasis in the lecture had been placed on thinking about what one might need to know about an organism, and the disease it caused, if one were to encounter the disease in a real life situation. Emphasis in the lab was on design and implementation of a class-designed study of an authentic medical problem. I had ample subjective evidence that most students were beginning to see what to do when their research needed new direction, and I was certain that they were perfecting lab skills that are essential for diagnostic work. However, I was not sure if they could combine the skills from lab and knowledge from lecture, apply them to a new problem, and confidently choose a course of action. Student performance on the final exam left no doubt that learning the process enabled them to apply the knowledge to a new scenario. All of the students had constructed a framework of knowledge and skills to which they could attach new information and on which they could develop new ideas and create new responses.

The power of this kind of instructional and assessment format was dramatically illustrated by one student in particular. I had considered this student's performance to be marginal, both in terms of participation and exam scores until the last assessment. I would have comfortably said that this student simply was not performing at a level compatible with passing the course. However, her performance on the final exam left no doubt that she was more than capable of using what she knew to solve a problem. (I have appended a copy of this student's paper to illustrate this finding: see Appendix 5B.)

Using their responses to the final exam question, I could say with confidence that the students showed remarkable gains in their ability to synthesize, analyze, and evaluate within the context of microbiology. However, even this class of adult learners was unable to discuss their learning in those terms. Nor could they read a definition of learning and apply it to their own experience. When pressed to discuss their own learning, they simply iterated their experience and referred to the tasks that they could now perform. Certainly their view of what they had learned was not consistent with my analysis of the level of their achievements. As I reflect on this disparity, I wonder if this is based on their unfamiliarity with discussing and perhaps even thinking about their own learning.

This type of lab approach proved to be a powerful tool for stimulating meaningful student learning and appropriate assessment. It was equally as powerful a tool for instruction. Comparing my instruction in this semester to previous semesters, I find that the focus has changed from instruction to learning; from what was taught to what was learned; and from what was important to me to what was important to the students. The students directed the learning and I facilitated it. It became a remarkably comfortable role for me, and the outstanding results validated the process.

I found that it is important to talk to students about what constitutes learning and how it occurs. I believe now that knowing how to do something cannot be separated from knowing why something is done. My teaching has changed markedly, and if the performance of this class is a benchmark, the changes will be as beneficial to my students as they are to me.

GENERAL FINDINGS AND COLLABORATIVE REFLECTIONS

The results of our surveys at all five sites indicated that students had no difficulty identifying activities that were important in promoting learning. One interesting finding is that all five groups consistently ranked group discussions very highly. Many also cited activities which required the use of thinking and logic as important. We found these commonalities surprising since the sample size was very large and the research population was quite diverse. The students ranged in age from fifteen to over thirty in the research sample, and their interests and experiences also varied widely.

The finding that was even more intriguing for us, however, was the fact that students and teachers alike have difficulty articulating a

definition of learning and using that definition as evidence that learning has occurred. The surveys and individual interviews with students revealed two pervasive ideas that students hold about learning:

1. When asked for evidence that they had learned, students tended to give examples of unique and highly individual activities that they could do as a result of their experiences. For example, they felt that being able to respond to questions and being able to answer questions based on their own analysis is evidence that they have learned. One student said, "When you know only facts, you can answer only 'prepared' questions. When you know something, you can formulate your own ideas and state your own ideas about something." Additionally the ability to participate in conversations about what they know was seen as significant evidence of learning. The following quotes came from students: "I can take part in conversations about muscles and bones with my college friends who are pre-med students." "I am now able to discuss these concepts intelligently. Understanding gives me such confidence—it is like finally completing work on a violin concerto." In the "can do" area, another student responded, "We were able to create a system that reached equilibrium and to change that system. This is something I was not able to do beforehand." Still another stated, "I can go into the lab and do any procedure that is set in front of me."
2. Students identify a strong link between learning and relevance. Learning is thought to occur if there is some relevance to their own lives—if they can make a connection between what happens in the classroom and what happens in their own lives. They cited such examples as, " I can now point out on my body where my muscles are and what bones they are moving. I was not able to do this before, so I have learned." Another student linked her classroom experience to her exercise program, "When we studied the muscles, I was able to identify them both on the pig and the human body, and when I worked out, I knew what muscles I was using and what was going to be sore."

As teachers we continue to struggle to clarify our own understanding of what constitutes learning and what we will accept as valid evidence that learning has occurred. Emerging from our convoluted and continuing debate seems to be the theme that real learning which has significance both for us and our students may not be measurable within the confines of our classroom.

In his article titled "Let's Declare Education a Disaster and Get On with Our Lives" (Smith, 1995), Frank Smith outlines several insights that bear directly on our work:

> Instead of talking all the time about what teachers should teach and what students should learn, we should talk more about what teachers and students should do...At one time it would have been ludicrous for parents interested in knowing what their children were learning at school to be fobbed off with a grade-point average or a relative position in the class. They would want to know what their children could do (p. 590).

Smith concludes by saying that the sole justification for education may be that students and teachers are mutually engaged in sensible and productive activities.

Perhaps our challenge as teachers is to design important instructional activities which create significant changes in what students know and are able to do, to talk with them about learning, to encourage them to find meaning beyond the classroom, and to admit to them and ourselves that reaching a common understanding of what constitutes real learning may not be an achievable goal.

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APPENDIX 5A

SURVEY INSTRUMENT A

STUDENT EVALUATION OF CLASSROOM ACTIVITIES

1. Which of the following learning activities did you do during this unit? (please circle)
   a. Working as a team
   b. Team presentation
   c. Using community members as resources
   d. Using thinking and logic
   e. Guest speakers
   f. Creating your own experiments
   g. Projects
   h. Field trips
   i. Logs/journals
   j. Lectures
   k. Step- by-step direction for experiments
   l. Worksheets
   m. Reference materials
   o. Textbook
   p. Classroom discussion
   q. Tests
   r. Chapter review questions
   s. Other: (please describe) ________________

2. Of the activities you circled, which were the most helpful in increasing your understanding of the topic? (Please note: This does not mean which ones you liked the most, but rather which ones helped you learn.) Please explain your answer.

3. Of the activities that you circled, which were the least useful in increasing your understanding of the topic? (Please note: This does not mean which ones you liked the least, but rather which ones were least helpful in helping you learn.) Please explain why.

SURVEY INSTRUMENT B

STUDENT EVALUATION OF LEARNING

Please read the following definition of learning:

Through learning we become able to do something we never were able to do. Through learning we reconceive the world and our relationship to it. Through learning we extend our capacity to create, to be a part of the generative process of life.

1. Based on this definiton of learning, what evidence can you give us that you have learned?

2. Which activities helped you:
   a. do something you could not do before?
   b. change your perception (mental image) of something?
   c. extend your capacity to create something significant?
   d. change the way you see yourself in relation to your world?

SURVEY INSTRUMENT C

INDIVIDUAL STUDENT INTERVIEWS

1. What did you learn in this unit?

2. How do you know?

INTERVIEW QUESTIONS FOR SELF-DIRECTED LEARNING UNIT

1. In this unit, was creating your own investigation important to your learning?
   a) if not, why not?
   b) if so, how?

2. Did you think presenting your project was valuable?
   a) if not, why not?
   b) if so, how?

3. Did listening to other projects help your learning?
   a) if not, why not?
   b) if so, how?

4. Did you learn more or less with this unit than you usually learn in more traditional teacher-directed units?
   a) if more, why?
   b) if less, why?

APPENDIX 5B

Name:________________

ID#:________________

MOLB 2220

DUE DATE: Wednesday, May 10, 8am, PS 339 (my office)
ATTACH THIS PAGE TO THE FRONT OF YOUR ASSIGNMENT.
Answer the questions regarding the case below. Indicate the question that you are answering and type and double space your answers.

"The Mystery in Mongolia"

After years of debate and planning, you have finally realized your dream of a month long exploration of a vast and untamed area. While some would call your trip a vacation (and, yes, some would call it crazy) you see this as an opportunity to not only escape from the pressures of your position, but also to broaden your global perspective and enhance your understanding of another culture. Your trip will take you deep into a country where nomadic people thrive herding goats in high plains steppes not unlike those found in Wyoming. After traveling for five days on a small Mongolian horse, you arrive at the camp of the families with whom you will spend the next twenty days. Your arrival is greeted with great concern, however, as most of the people in the camp are not well. As your guide translates, an older woman explains that the entire tribe is ill. The children are the weakest, but no one feels like herding goats. As you observe the camp, you note that the goats are huddled together and few are grazing (a sure sign of an unhealthy goat) and that even the dogs look depressed. Amongst the caprids (goats) and the canids (dogs) it appears to be the youngest again that are the weakest. Wishing you had just gone to Maui but realizing that you are the only person for a five day ride who has **any** advanced knowledge in the medical fields, you know that you must help.

Questions:

1. What knowledge and skills from your previous experience will be helpful to you in working on this problem?
2. What further information do you need about the case?
3. How will you collect this information?
4. Now that you have gathered this information, what are you going to do with it? (Hopping back on the Mongolian pony and riding into the sunset is not an appropriate choice.)

SAMPLE STUDENT RESPONSE TO "FINAL EXAM"

1. *What knowledge and skills from your previous experience will be helpful to you in working on this problem?*

   In the beginning of our microbiological course, there was an overview of how the immune system works and protects us from everyday encounters with potentially harmful agents. I learned how the body reacts when certain organisms attempt to defeat the immune system. This could range from the phagocytic action of the white blood cells to hypersensitivity reactions. While a battle is taking place within the body, signs are given off as an indication. These signs may include inflammation of mucosal membranes resulting in a sore throat or swollen eyes, body aches and stiffness, bodily temperature change, or diarrhea. Since different microbes yield different symptoms, further learning was completed about host and tissue specificity, meaning who and what certain microbes can attack. Age differences, previously obtained immunities, geographical locations, culture differences, and whether or not a microbe is zoonotic are all important factors that need to be looked at when determining this. The next course of study dealt with epidemiology. Modes of transmission, portals of entry, and reservoir types were included in this learning. By studying all of these characteristics for specific diseases, it helps a person to identify specific organisms.

   Because of this knowledge, one should be able to narrow down a particular list of what could be causing an illness. This is where I would start. Applying this previously learned knowledge to the Mongolian tribe illness and narrowing it down to a questionable list.

   Other previous learning that could apply to this scenario would be my laboratory experience. This gave me skills in how to conduct an experiment using the scientific approach. Once a hypothesis regarding the unknown illness is formed, it needs to be tested. The laboratory project made it apparent that there are numerous steps to be taken. It was hands on training and not trying to interpret a confusing medical book or article. So this experience is very important in that it identifies where you need to start and what to expect.

2. *What further information do you need about the case?*

   To begin with, the symptoms need to be identified in all of those affected. Just the fact the entire tribe along with its goats and dogs are having a lack of energy isn't enough. We need to know what bodily signs are being given off, such as a fever being present, vomiting, diarrhea, rashes or lesions, or extreme weight loss. This information needs to be identified so it is clear what part of the body is being affected. Diarrhea might indicate an intestinal infection, or violent coughing could indicate a respitorial problem, and so on. By knowing which part of the body is being compromised, it enables you to narrow down what organisms might be causing the problem.

   Other important information needed includes knowing the tribe's food and water sources. Since the entire population is being affected, the problem could be a common point source epidemic. Another possibility is that the goats or dogs first contracted the disease from their own food and water sources and then passed a mutated disease form to the tribe through simple contact.

   Another thing to examine would be the possible presence of vectors within the population. There is always the chance that the disease is being spread by

ticks or mosquitoes, and that is what needs to be controlled.

A good thorough look at the tribe's everyday habits should be done. This would include food, waste, goat, and carcass handling. Hygiene is also a biggie. There is a big possibility that the techniques being used by the tribe are the reasons for why the disease is being spread. It is extremely important that the mode of transmission be identified since it also helps to narrow down your list of possibilities.

3. *How will you collect this information?*

Ways of collecting this information could be a little difficult. In order to help this tribe, a person would need a little more equipment than what the little Mongolian pony would allow you to carry. But assuming that the necessities are all present, these are the steps that would be performed in order to collect information. To start off with, fecal, urine, and blood samples need to be collected and cultured out to look for microbial growth. Also, samples of mucus secretions should be taken. These tests would indicate if a bacteria, virus, fungus, or parasite is causing the illness. The list is being narrowed down even further.

A study of the surrounding areas should be performed. If there is a possibility of vector transmission, then it needs to be determined if there is a larger population of vectors in tribal and goat areas than in other places. A larger number would indicate that the vectors are a possible cause. Also, if there is a large number of these vectors in the carcasses of victims, that is another big sign.

Information regarding mortality rate and the time between the onset of the illness and death should be collected. This would give you an estimate of how long you have to conduct the study before the entire population is wiped out or you yourself become infected.

4. *Now that you have gathered this information, what are you going to do with it?*

There are two possibilities that could happen here. Either you start all over realizing that your previous steps have lead you in the wrong direction, or a complete analysis of the situation should be made. Hopefully, the latter is the case. If so, this is what would happen. We must first assume that I have made a fairly accurate guess about the organism that is causing the sickness, and because of this knowledge, how to prevent or control further disease spread would accompany this guess. If it is indeed everyday actions that are contributing to the disease spread, then action needs to be taken to help the tribe change their ways. As far as prevention goes, drug choices need to be made. Should antibiotics or antihelmenthic drugs be used? What about vaccines? If the microbe is a virus, what kind of actions will help to stop the disease spread? Endless possibilities need to be tested. Any which way, the disease at hand needs to be controlled before it becomes too controlling itself. After this is completed, I can hop back on my Mongolian pony, by then probably sick, and ride into the sunset with a headache and a bunch of information that I'll hand over to some professors that will end up hacking it apart anyway. Oh well, that's research.

APPENDIX A
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APPENDIX B
SUGGESTED READINGS

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